54th YEAR OF PUBLICATION

Engineering News

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FOR MEMBERS ONLY

Pakistan Engineering Congress is a prestigious professional body established in 1912 dedicated, interalia to technical advancement of Science & Engineering in the country.

NO MORE APATHY, PLEASE !

Call it apathy, casual attitude, indifference or even procrastination ; these have unfortunately penetrated deep into the daily behavior of ours in our society. If not most, but we can say many show apathy towards almost every matter, except perhaps when it affects one's personal interest. A cabinet minister may be interested in anything except the affairs of his own ministry towards which attitude would be just casual. A teacher in a government school, a doctor in a state run hospital, a baboo in a district government office, all unfortunately appear to suffer from this behavioral disorder. That is not all. Many important meetings, be it the session of the legislative assembly or of the councilors in a municipal corporation have to be postponed for lack of quorum, which happens thanks to this very characteristic of ours that is being lamented here.

We don't have to go too far. Interest shown by the members in the Pakistan Engineering Congress meetings leaves much to be desired. The seminars & symposia even on important issues are not very well attended. This very journal whose lines are being used to voice concern on this problem with our society is seldom printed in time because response of the members towards requests for contributions is very poor. Reason is the same, apathy towards these requests as well as the journal.

Corrigendum

In the Editorial published in July-December, 2012 issue of the journal, the GDP of Pakistan was inadvertently shown as Rs. 240 billion. The actual amount of the GDP is US $ 240 billion.
The mistake is deeply regretted.

Report on

Inauguration of the Centenary Celebrations (1912-2012) of Pakistan Engineering Congress at Khurshid Mahal Hall Avari Hotel Lahore at 10:00 A.M. on 31st December, 2012

The Chief Guest of the event was the Honourable Ch. Qamar Zaman Kaira, Federal Minister for Information and Broadcasting. Upon arrival, he was received by Engr. Husnain Ahmad, Immediate Past President, Engr. Rana Khursheed Anver, Senior most Vice President along with the members of the Executive Council.

A group photo of the Executive Council was taken with the Honourable Chief Guest. The proceedings started with the recitation from the Holy Quran, after which, Engr. R. K. Anver, Senior most Vice President presented, his welcome address to the Chief Guest.

Engr. R. K. Anver, Senior most Vice President, spoke about the landmark achievements of Pakistan Engineering Congress, established in 1912. He apprised the Chief Guest that the Congress is the oldest professional, non-Governmental, non-profit charitable and non-Political Organization of the country and its office bearers are all professional engineers and work in an honorary position during their tenures of office. The Chief Guest was apprised that the congress website shows 1500 research and practical published papers accessible world-wide cost free. He went on to say that based on the research work presented from this forum the largest irrigation network in the world was indigenously developed by the local irrigation engineers.

The Chief Guest was informed that the Congress had instituted 444-scholarships for 4-year engineering studies 300 of which are still being funded at the rate of Rs. 4000 per month and almost 100-scholarships are being added every year, its computer college has imparted professional I. T. courses to 7900 engineers, students etc. at an extremely nominal subsidised fee.

Engr. R. K. Anver, Senior most Vice President, lamented that it is a pity that no new large water storage dam has been built in Pakistan during the last 26 years. Tarbela and Mangla were built only as replacement structures and were not meant by any means for development purposes. Indus Waters Treaty of 1960 and the Inter-provincial Water Accord of 1991 held out assurances for building more dams for irrigation and hydropower development. Pakistan Engineering Congress, the Technical experts at home and abroad, the National Press and all the saner elements have been advocating for the construction of new storage dams since then but haplessly their recommendations have not been heeded.

Engr. R. K. Anver, Senior most Vice President, spoke highly of the visionary reforms introduced by the Quaid-e-Awam, Shaheed Zulfiqar Ali Bhutto resulting in posting of high caliber engineers as Secretaries and Chief Executives of Technical Ministries and Corporations. However, these valuable reforms have been reversed by the generalists, bureaucrats, demoralizing the engineering community resulting in brain-drain and consequent economic set-backs.

Engr. R. K. Anver, Senior most Vice President, appealed to the Honorable Chief Guest to get these reforms re-enacted, may kindly move the Government to confer time-scale promotions on engineers working in Federal / Provincial Government Departments and above all grant "Service Structure" for the engineers, case in-respect of which is languishing for decades and for formulation of which the Federal Government has recently constituted a high-powered Committee (and a reference about which is lying for quite some time with Government of Punjab).

Engr. R. K. Anver, Senior most Vice President, said that the present is an age of scientific development and rapid advancements in nuclear energy, high speed trains, high-rise buildings, motorways and flyovers, major dams and hydroelectric generation and information technology. Advances in engineering and technology are bringing together the developed countries into

virtually a single global economy. In the process, the developing countries, which do not have an access to the knowledge and technology, are being slowly pushed out of the mainstream. We have superb climate which makes it possible to grow crops round the year. Our people are patriotic and hard working. We have engineers, scientists and technicians who are talented. Given the opportunity, they make their mark of excellence. He further said that "Research and Development" is another area which has been neglected for too long. We are spending hardly 0.15% of our GDP on Research and Development whereas in developed countries, the ratio is more than 1.5% of GDP. Lack of support to Research and Development is, unfortunately, widening technological gap between the developed and developing countries, therefore, there is an urgent need to accelerate our efforts in Research & Development".

Engr. R. K. Anver, Senior most Vice President, once again thanked the Honorable Chief Guest for gracing the occasion with his presence despite his intense preoccupation.

The Honorable Chaudhry Qamar Zaman Kaira extolled the monumental achievements of Pakistan Engineering Congress, for uploading on its website about 1500 technical papers of high caliber on diverse engineering issues / projects accessible free of cost, for imparting professional I.T courses at extremely low fee to over 7000 engineers, students by now, for implementing a sustained scholarship programme for facilitating engineering education at Engineering Universities all over Pakistan, a very commendable performance.

The Honorable Minister said that he feels elated to be told that it was the Quaid-e-Awam Shaheed Zulfiqar Ali Bhutto who introduced monumental engineering reforms and it has distressed him to know that these monumental reforms have been reversed by the vested interests. He advised the Congress to send him a brief on the present status of the case of engineers Time Scale Promotion / Service Structure and promised to move the concerned authorities to finalize it expeditiously. He said that engineers were surely contributing a lot to the country's defence and infrastructural development. The private sector's role was equally commendable, as it provided forum to engineers to polish their skills. The Honorable Minister further said that Pakistani engineers and doctors had proved that they were second to none in the world, which was a great pride for the country. No doubt, developed world spent a major share of their budget on research and development, however, Pakistan being a developing state, had meager resources in this regard.

He remarked that it is ironical that only the politicians were always widely criticised but no one asks how much period they ruled the Country and under what circumstances.

The Honorable Minister said that it was a fact that no mega dam was constructed in Pakistan during last many years, which was major cause of power shortage and its higher tariff, but we have to pinpoint those rulers who failed to embark on such projects of national importance.

The Federal Minister pointed out that last regime had laid foundation stone of Diamir Bhasha Dam but did not purchase even an inch of land for the mega project. Contrary to this, he added, the present government had worked out that the previous project during last three and a half years and now the project was at tendering stage. He requested adoption of a rational approach to the problem which is confronting a number of Nations all over the world.

At the conclusion, the Chief Guest again thanked the Pakistan Engineering Congress and Engineering Community for assembling such a distinguished gathering of Engineers, Scientists and young Professional Engineers.

Publications issued at the Centenary Celebrations (1912-2012)

At the auspicious occasion of the centenary celebrations, the Congress released following publications and distributed complimentarily to members of the Congress, concerned Federal / Provincial government departments, engineering universities, libraries etc.

1. **Volume of Annual Proceeding papers**

The Book contains 25-technical papers on diverse engineering projects/issues that were presented at 5-Technical Sessions.

Discipline	Papers Presented
I. **Hydropower**	5
II. **Floods and Hydraulic Structures**	4
III. **Water Resources**	6
IV. **Construction Highways**	4
V. **Miscellaneous**	6

2. **History of the Congress (1912-2012)**

The history of the congress was earlier printed at the "Diamond Jubilee" in 1987 covering the period from the inception of the congress in 1912 (1^{st} – 61^{st}) session. A need was felt to release the history from 1912 to 2012 (1^{st} session to 72^{nd} session). Hence, the history was revised and re-edited from 1^{st} to 61^{st} session and compiled for the period of 62^{nd} session to 72^{nd} session and re-issued, studded with memorable pictures. The updated history has been released in 2-volumes containing 703-pages.

3. **Performance of various Engineering Departments / Organizations**

At its Diamond Jubilee Celebrations in 1987, the Congress issued a number of Publications, including a "Special Publication", containing a concise background history of achievements and future plans of the various Private/Public sector organizations to highlight and recognize the pivotal role of 'Engineers' in planning and establishment of projects of national importance as well as to provide valuable information.

At the Centenary Celebrations, the achievements of 19-leading public / private sector organizations were collected in a special volume containing:-

- The overview of the Organization`
- Past achievements/projects with photographs
- Ongoing projects of importance
- Future plans and projects in pipeline

This volume is a landmark centennial publication and is expected to be useful for all professionals.

4. **Summaries of Gold Medal Papers (1912-2012)**

About 20-24 papers are presented at the Annual Session of the Congress and 8-10 papers at the Annual Symposium. In recognition of the contribution of the authors of the papers presented at the annual session which were adjudged as the best, the Congress initiated the award of "Congress medal" in 1917. Kennedy Medal was instituted in 1918 for the best paper in the field of "Irrigation and Drainage". Dr. Mubashir Hassan Medal was started in 1974 for the best paper presented at the Annual Symposium and Dr. Manzoor Hussain Bukhari medal is to be awarded for the best paper on land drainage.

In view of the rich technical value of these monumental papers, summaries of 52-papers proceedings were ably prepared by Engr. Dr. Ch. Mazhar Ali and issued in a book form and presented at the 64th Annual Session (1992-94). The enlarged edition of this publication covering the period to 1912-2012 (1st Annual Session to 72nd Annual Session) has been issued with summaries of additional 12 papers prepared by Engr. Syed Mansoob Ali Zaidi, Vice-President (PEC).

5. **Symposium on "Emerging Phenomenon of Untimely Rains / Floods-2011 in Pakistan"**

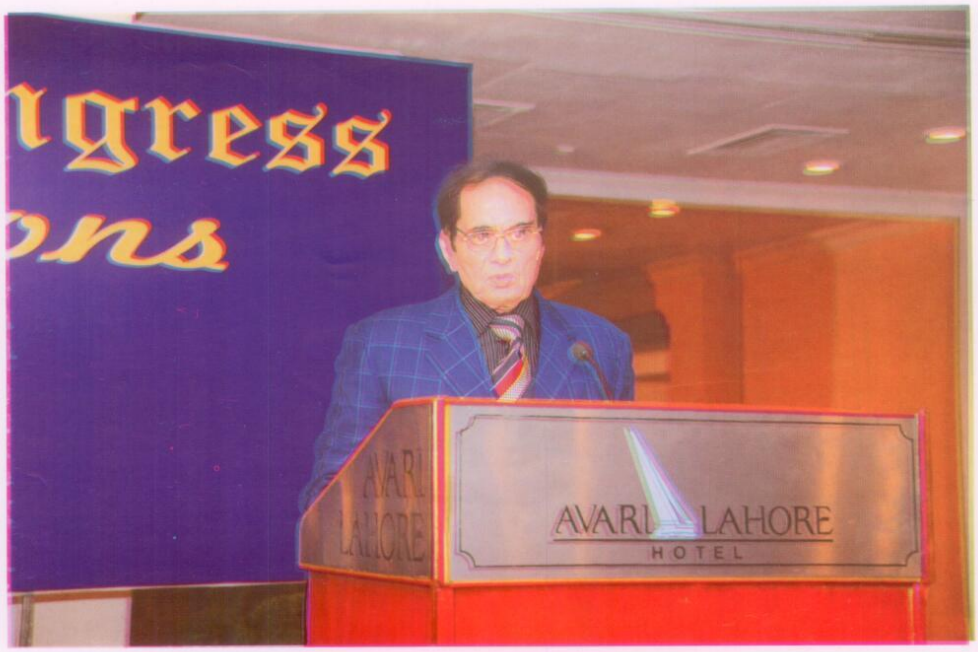
The Symposium was held on the above cited topic on 3rd January 2013 in line with the policy of the congress to hold a symposium on a subject of current significance at its annual session. Already 33-volumes of the papers presented in the past have been published. The present 34th volume contains 11-papers by eminent water resources experts, meteorologists and experts on the phenomenon of Floods, Untimely Rains/Flash Floods delineating Short Term/Long Term measures that need to be adopted to combat this recurring menace to minimize the damage to life, property, infrastructure etc. as well as to conserve and utilize the flood water.

From Left : **Engr Akhtar Abbas Khawaja,** Vice-President / Secretary PEC, **Engr. S. M. A. Zaidi,** Vice-President PEC, **Engr. Ch. Ghulam Hussain,** Vice-President PEC, **Engr. Husnain Ahmad,** Immediate Past President, **Engr. R. K. Anver,** Senior most Vice-President PEC looking for the arrival of the Chief Guest

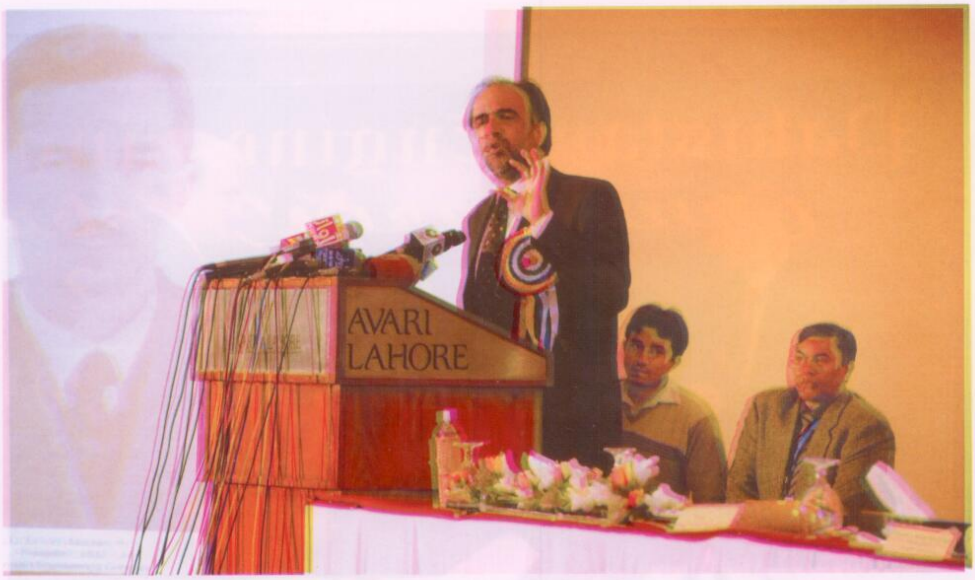
The Chief Guest, the Honorable **Chaudhry Qamar Zaman Kaira**, Federal Minister for Information and Broadcasting being received by the members of Executive Council of the Congress

Group Photo
Front Row (L to R)
Engr. Rana M. Aslam Chohan; Engr. Pir Muhammad Jamil Shah; Engr. Dr. Izhar-ul-Haq; Engr. Syed Mansoob Ali Zaidi; Engr. Najam Waheed; Engr. Husnain Ahmad; Engr. Rana Khursheed Anver ; **The Honorable** Ch. Qamar Zaman Kaira (Federal Minister for Information & Broadcasting); Engr. Akhtar Abbas Khawaja, Engr. Ch. Ghulam Hussain; Engr. Ch. Muhammad Arif; Engr. Muhammad Amin; Engr. Tariq Rasheed Wattoo; Engr. Sheikh Saeed Tahir; Engr. Ijaz Ahmad Cheema
Back Row (L to R)
Engr. Anwar-ul-Hassan; Engr. Capt. (R) M. Qadir Khan; Engr. Muhammad Ibrahim Malik; Engr. Ch. Foad Hussain ; Engr. Jamil Basra

From Left: **Engr. Akhtar Abbas Khawaja**, Vice-President / Secretary PEC, **Chaudhry Qamar Zaman Kaira,** Federal Minister for Information and Broadcasting, **Engr. R. K. Anver,** Senior most Vice-President PEC



Engr. R. K. Anver, Senior most Vice-President Pakistan Engineering Congress presenting the Welcome Address for the Chief Guest



The Chief Guest **Chaudhry Qamar Zaman Kaira,** Federal Minister for Information and Broadcasting delivering the Inaugural Address at the event

Engr. Husnain Ahmad, Immediate Past President presenting vote of thanks to the Chief Guest the Honorable **Chaudhry Qamar Zaman Kaira,** Federal Minister for Information and Broadcasting

From Right : **Engr. Husnain Ahmad,** Immediate Past President PEC, **Engr. R. K. Anver,** Senior most Vice-President PEC and **Engr. Akhtar Abbas Khawaja,** Vice-President / Secretary presenting shield to the Chief Guest **Chaudhry Qamar Zaman Kaira,** Federal Minister for Information and Broadcasting

From Right : **Engr. R. K. Anver,** Senior most Vice-President PEC, **Engr. Tariq Hameed,** Former Federal Minister for Water and Power / Former Chairman WAPDA (Chairman Technical Session), **Engr. Dr. Izhar-ul-Haq,** Vice-President PEC, **Engr. Akhtar Abbas Khawaja,** Vice President / Secretary PEC

From Right : **Engr. R. K. Anver,** Senior most Vice-President PEC presenting shield to **Engr. Tariq Hameed,** Former Federal Minister for Water and Power / Former Chairman WAPDA for Chairing the Technical Session

From Left : **Engr. Hasnain Afzal,** Member Water WAPDA, **Engr. Ch. Ghulam Hussain,** Vice-President PEC, **Engr. R. K. Anver,** Senior most Vice-President PEC

From Right : **Engr. R. K. Anver,** Senior most Vice-President PEC presenting shield to **Engr. Ch. Ghulam Hussain,** Vice-President PEC for Chairing the Technical Session, **Engr. Hasnain Afzal,** Member Water WAPDA is also seen in the picture

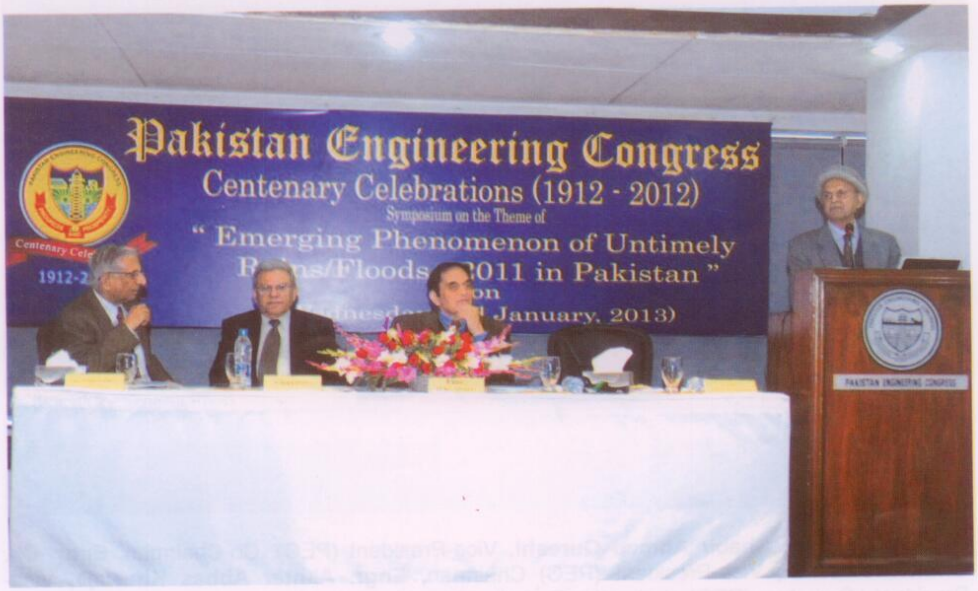
From Right : **Engr. R. K. Anver,** Senior most Vice-President PEC presenting shield to **Engr. Hasnain Afzal,** Member Water WAPDA for Co-Chairing the Technical Session

From Left : **Engr. Ch. Muhammad Rashid Khan,** Past President (PEC), **Dr. Muhammad Abid Bodla,** Member Infrastructure Development (P & D) Punjab Chairing the Technical Session and **Engr. Akhtar Abbas Khawaja,** Vice President / Secretary (PEC)

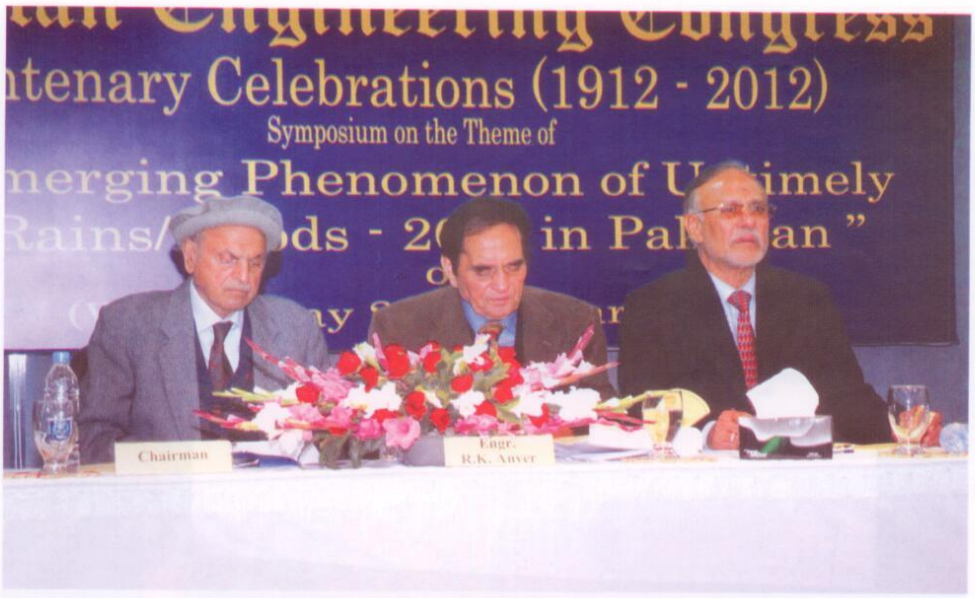
From Left : **Engr. Iftikhar-ul-Haq,** Member Executive Council / Convener Symposium Committee, **Dr. Amjad Agha,** Chairing Technical Session and **Engr. R. K. Anver,** Senior most Vice-President (PEC)

From Right : **Engr. R. K. Anver,** Senior most Vice-President (PEC) awarding shield to **Dr. Amjad Agha** for Chairing Technical Session

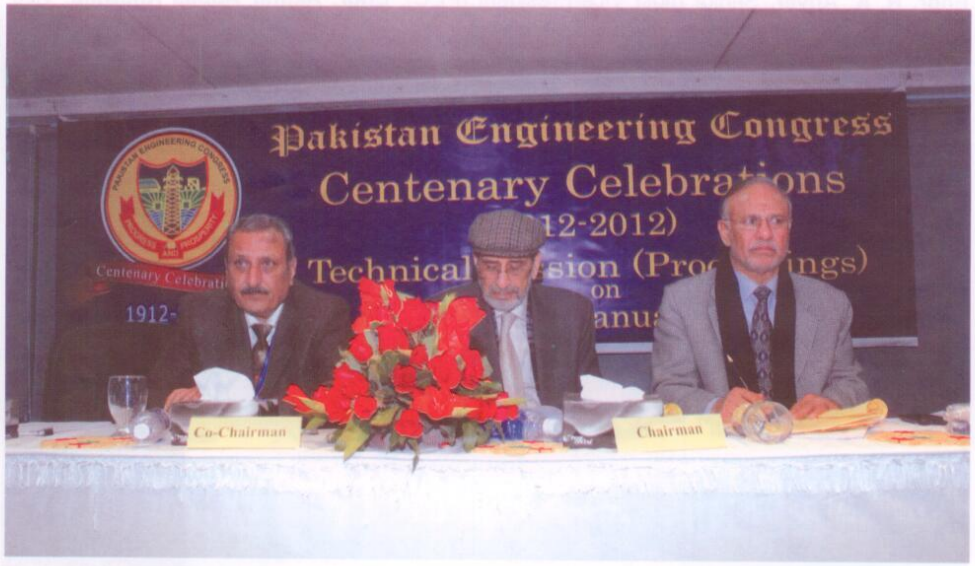
From Left : **Dr. Asad Sarwar Qureshi, Engr. Riaz Nazir Tarar,** Chairing Technical Session, **Engr. R. K. Anver,** Senior most Vice-President (PEC), **Engr. Akhtar Abbas Khawaja**, Vice-President / Secretary (PEC)



Engr. Riaz Nazir Tarar, presenting his paper on the topic of **"Pakistan Proposed Approach to Flood Control and Management Based on 2010-Experience"**
From Left : **Engr. Iftikhar-ul-Haq,** Convener Symposium Committee, **Engr. Dr. Amjad Agha,** Chairing theTechnical Session, **Engr. R. K. Anver,** Senior most Vice-President (PEC)



From Left : **Engr. Riaz Nazir Tarar,** Project Manager, Bhasha Dam, **Engr. R. K. Anver**, Senior most Vice-President (PEC) and **Engr. Akhtar Abbas Khawaja,** Vice-President / Secretary (PEC)



From Left : **Engr. Shabir Ahmad Qureshi,** Vice-President (PEC), Co-Chairman, **Engr. Ch. Ghulam Hussain,** Vice-President (PEC) Chairman, **Engr. Akhtar Abbas Khawaja,** Vice-President / Secretary (PEC) during the Technical Session of the Centenary Celebrations (1912-2012).

A view of the audience

A view of the audience

A view of the audience

A view of the audience

A view of the audience

RECOMMENDATIONS

Symposium on
"Emerging Phenomenon of Untimely Rains/Floods 2011 in Pakistan"

Paper : **Adaptation to Untimely Floods**

Author : ***Kamran Emami and Saeed Pourshahidi***

Recommendations:
The most important challenge of the flood engineers in the 21st century is to design and construct safe and low cost hydraulic structures in the shortest time possible with uncertain design parameters. Solution of this problem will above all require adopting a holistic and adaptive approach. The main strategies of the holistic design are;

- Ensure a flexible and adaptive design in view of hydro system changes and the inherent uncertainties of water engineering.
- Establish the interdependence of structural and non-structural approaches in design. In this context management of hydraulic structures should be designed too.
- Adapt to the stochastic nature of river flow by integration of seasonal characteristics and river forecasting.
- Learning while doing
- Recognize the uncertainties of risks of project and design hydraulic structures to adapt to extreme events far larger than design parameters and remain inherently safe (structural ductility and resilience)
- Base the design on comprehensive management and flexibility
- Enhance safety by 'designing' emergency and crises management preceding the events and in real time for the structure and downstream population centers.

In the past decade the holistic design has been used for several water projects including dam construction, flood management and value engineering studies. In all the cases the holistic design has resulted in enhanced safety and reduced cost and construction time.

Paper: **Estimating Flood – 2010-11 Extent Using Satellite Remote Sensing Data in Pakistan**

Author: ***Badar Ghauri***

Recommendations :
The value and usefulness of timely collected and processed satellite images are demonstrated through the mapping activities in recent floods. In addition to the free land sat images, which have limitations in timely revisits and cloud cover requirements, the other images, such as radar images, from the international Charter are a valuable data source. Archived images and GIS data are needed to detect reliable flood extent and estimate potential crop and infrastructure damages. The combined use of temporal optical and radar images is often necessary to achieve this objective. Web mapping capability provides the general public and government agencies with an effective tool for situation awareness and development update.

Paper: **Emerging Phenomenon of Untimely Rains Floods in Sindh and Ways to Mitigate their Damaging Effects**

Author: ***Jam Mitha Khan***

Recommendations:

The F. P. Bund (Flood Protection Bund)

Control of Hill torrents mainly depends on the F. P. Bund, the only reservoir to be considered in Hamal Lake, there being no other storage site along the route.

i. Strengthening of remodeling of F. P. Bund. The strengthening of the F. P. Bund includes measures from amongst the following:
   - Provision of adequate free-board by raising the height of the embankment
   - Increasing the top width
   - Flattening of side slopes
   - Upstream slope protection
   - Downstream berm for stability of the embankment Section where required
   - Sand coring in areas where embankment fill is poor
   - Proper treatment of embankment at sites where rat holes/animal burrows are detected.

ii. Catch Water Drain:
Construction of a catch water drain along the western side of F.P.Bund from Hamal Lake to ManchharLake so that obstructions due to low ridges along the storm water flow route are removed.

iii. Compartmentalization:
Construction of second line of defence in the area west of Shahdadkot, forming two compartments.

iv. Soaking Trenches:
Construction of trench bund or bunds to provide for soaking and testing of the F. P. Bund.

v. Construction of flood regulating / dispersion structures on some streams / Hill torrents.

vi. Hamal Lake Development:
Hamal lake storage of 88,700 AF at the Madde ridge elevation of 136 (MSL) could be increased to about 267,000 AF at the full reservoir elevation of 138 without any resettlement problem. The flows downstream Hamal Lake could thus be reduced.

Baran Nai

The existing facility includes the protection works for Kalri Baghar Feeder Canal super passage, which has recently been remodeled for Karachi Water Supply project. However, the Baran Nai torrents can possibly be controlled by constructing a dam at Darwat creating a large reservoir. Thus the stream flows downstream of the proposed dam site would be reduced. WAPDA has already started construction of a 60m concrete dam on this location.

Construction of Nai Gaj Dam

The floods of Nai Gaj dam can be reduced by constructing a dam to create a reservoir for mitigation of flood. WAPDA is in process of constructing an earth-core rockfill dam on narrow gorge. After completion of dam it is expected that flood impacts will be reduced.

Construction of Medium Small Dams

Construction of Medium and Small dams on Nai will help reducing the damaging effects of floods. A cascade of small weirs on a Nai will reduce the velocity of flows and will have delay action effects. Sindh Small Dams Organization has already constructed about twelve (12) dams in the area. Feasibility study has been prepared for additional 40 small and medium size dams in Kohistan, Karachi and Thatta area.

Paper : **An Appraisal of 2011 – Rain Damages in Sindh**

Author : ***Asjad Imtiaz Ali, Javeed Iqbal Bokhari and Qazi Tallat M. Siddiqui***

Recommendations:

During 2011 Rains / Floods, village abadies and cropped area were inundated mostly due to extensive rains in the rain/flood affected areas and inadequate surface/sub-surface drainage system in the main cities/towns, besides their locations in the depressions/low lying areas. Deferred maintenance of LBOD and other drainage systems considerably reduced the discharge capability of LBOD system and other drains which resulted in over topping of LBOD and other drains at various locations due to over-design discharge experienced in those drains during 2011 Rains / Floods.

Future strategies recommended in wake of 2011-Rains/Floods are as follows:

a) Proper survey of all rain/flood areas should be carried out in order to identify flood risk areas i.e. cities, towns, and villages, industrial areas etc. and proper drainage system of all main cities/towns should be designed so as to avoid such urban flood situation in future.

b) New settlements / abadies should not be allowed to settle in future in low lying area/depressions. For the existing abadies proper protective measures based upon detailed investigations / surveys may be adopted.

c) Proper pumping system should be installed for the existing urban areas, where gravity drainage is ineffective.

d) In view of the changing climate, floods have now become a common phenomenon in the country, therefore, flood management plans need to be formulated at district level clearly indicating the safe high grounds marked for immediate evacuation during the disaster and for establishment of flood relief camps. These plans must be well prepared and shared with all concerned organizations.

e) The close coordination of major stakeholder departments/institutions needs to be improved for efficient relief operations during the flood disaster.

f) The discharge capacity of LBOD and other drains needs to be enhanced keeping in mind the unprecedented rains / floods experienced during monsoon season-2011.

g) The issue of urban flooding caused due to poor drainage needs to be seriously dealt by district level authorities in collaboration with their concerned irrigation departments.

h) Loss of life and property can be minimized if appropriate disaster response plans, supported by reasonably accurate and reliable forecasts, are put in place and are well rehearsed. Hence Pakistan Meteorological Department needs to be well-equipped to give wholesome forecast indicating intensity and made responsible to issue early warning to all concerned departments. Although flood warning was issued, but its intensity was not known.

Paper : **Multihazard Vulnerability Scenario for Disaster Risk Management in Karachi**

Author : ***Yawer Ansari and Amir Sohail***

Conclusions:

Karachi city is particularly vulnerable to both earthquakes and tsunamis. The country's southern and southeastern regions are particularly vulnerable to large destructive earthquakes and form tsunamis generated by major seismic events associated with the MakranSubduction Zone. Major earthquakes may occur in the Kutch Graben, Karachi and Deltaic Indus Regions. From preceding discussions following conclusions are drawn.

1. City of Karachi is in close proximity of highly diverse and active Plate Boundary Fault Systems forming a Triple Junction in Arabian Sea in the southwest. In addition a number of active faults are present in the west, north and east of Karachi which almost surrounds the city.

2. The tectono-morphologic projections of faults in the north and northeast of Karachi permits southwards extension of these faults to be traversing through the city. This scenario poses a severe seismic threat to densely populated areas of the city.

3. A review of historical seismicity near Karachi reveals that it is located within striking distance of MakranSubduction Zone in the south, having the high probability of generating hazardous earthquakes of magnitude 8.0 and above resulting in generation of devastating tsunami.

4. Chaman-OrnachNal Fault System is an active Transform Plate Boundary Fault System which poses a significant 7.6 magnitude (Mw) in land seismic threat to the west of Karachi City. The seismic ground motion data indicates that such an earthquake if it is at a shallow depth, as the case may be, may induce mass devastation in Karachi on account of poor engineering practices, construction materials and a relatively low PGA value of 0.24 g adopted as per ZONE -2B, BCP Seismic Provisions-2007.

5. Kirthar Fault in north-northeast and Suljan Fault in the east of Karachi City are capable of inland seismic threats of magnitude (Mw) 7.8 and 6.8 respectively. The expected PGA values shall be of the order of +0.4 g which are much higher than the Zone – 2B recommendations of maximum 0.24 g.

Recommendations :

1. Multi Hazard Vulnerability Assessment of Karachi City and vicinity should be carried out on immediate basis by the City Government and/or provincial government Line Ministries and Departments to accomplish the following tasks:
   a) Development of Seismic Hazard Microzonation (SHM) Maps based on Total Hazard concept using GIS techniques.
   b) Provision of Safer Land use Maps of Karachi City and vicinity to mitigate and minimize the disasters effectively by geospatial solutions.
   c) Provision of more appropriate geologic, geotechnical and seismic design parameters for sustainable Urban Development.
2. Mitigation strategies along with contingency planning must be established and implemented to alleviate future impacts of envisaged disasters.
3. Existing building by-laws need an immediate drastic review to mainstream Disaster Risk Reduction (DRR)
4. Capacity building of stakeholders both with institutional and community based approaches to build the disaster resilience of urban population and to enhance the response capability of Government Line Departments.

Paper : **Unprecedented 2011 Rains / Floods in Pakistan and Actions Needed**

Author : ***Engr. Zafar Iqbal***

Recommendations:

Provincial Irrigation Departments and Federal Line Agencies may execute the remaining 2010-Floods damages rehabilitation/remodeling works on top priority basis, so as to ensure completion well before the start of monsoon season 2012. All urgent nature new flood projects as well as "O&M" works of flood protection infrastructure may be completed on priority basis before start of Flood Season 2012.

SIDA / PID Sindh may carry out the restoration and strengthening work of irrigation, drainage and flood protection infrastructure damaged during Monsoon Season 2011 on fast track basis to make the system ready for next monsoon season. The encroachments in flood plains and waterways / drains may be removed by the PID Sindh / SIDA with the help of Districts Administration in order to enhance the discharge capacity of drains and minimize the loss of human lives and damages to the property in future floods. SIDA / PID Sindh may also carry out feasibility studies for long term measures/permanent solution of drainage problem in order to avoid 2011 like situation in future. The following options may be given due consideration, while formulating proposal ;

- Remodeling and enhancing the discharge capacity of existing drainage network on the basis of torrential rains experienced during Monsoon Season 2011.
- Construction of an independent natural Dhoras Network and Syphons across Main Drain for diversion of flows into Dhora Puran (Shakoor Dhand) in order to off-load LBOD System.
- Construction of out-fall structure along Kadhan Pateji Outfall Drain (KPOD) to control tidal impact and sea water intrusion.
- Remodeling of weirs and increasing size of inlets and culverts etc. constructed across drains.
- Diversion of storm-water to Dhands of Thar desert such as Kakao, Kalankar and abandoned Dhoro Puran etc.
- Identification of natural depressions, their strengthening for enhancing their storage capacities and identification of accessible high elevation areas for settlement of rain / flood affectees in future floods.

Paper : **Rainfall Deluge Management – A Case Study of Sindh Province in Pakistan**

Author : ***Muhammad Idris Rajput***

Recommendations :
Rainfall deluge of August / September 2011 created an emergency situation which could not be managed properly. There should have been a "Contingency Plan" and an "agency" to implement this plan. There are NDMA and PDMA but these are organizations having contingency plan inadequate to implement it. SIDA, the in-charge organization, lacks management skills and expertise to face the emergency situation. SIDA should prepare a more specific contingency plan and should be responsible for its implementation. Similarly district administration should have their own contingency plan in line with PDMA and SIDA so that they have not to wait for further instructions.

The drainage tubewells in LBOD drainage area should be maintained and operated as per design criteria of keeping sub soil water level 5-7 feet below ground so that some quantity of standing rain water is absorbed through infiltration.

Carrying capacity of existing drainage system should be enhanced to take care of increased rainfall intensity. Existing escapes on canal system should be maintained properly and their capacities be increased for increased discharges in canals. Ring bunds should be constructed around towns which are likely to be inundated by flow of rain water from adjoining areas.

Gates should be provided in sub-drains and branch drains which outfall into LBOD to control back flow. Abandoned natural waterways should be reactivated to dispose rainwater through them to sea.

Drainage cover should be provided in areas where there is no drainage at present.

REVIVAL / ACTIVATION OF ABANDONED NATURAL WATERWAYS (DHORAS)

The present drainage system is of recent origin, whereas monsoon rains have been falling prior to construction of present drainage system. How rain water used to be drained then?

Prior to development of weir controlled irrigation system in Sindh and Riverbunds, River Indus used to meander at its sweet will through various branches in Sindh.

These river branches were curtailed / blocked after development of weir controlled Irrigation system and river bunds. However, these formed natural drainage routes for disposal of rain water. With development of society and increase in population, these natural drainage routes were encroached upon or blocked by people for extension of existing towns, construction of villages and agricultural development etc. Parts of Digree, Naukot and Jhuddo towns are constructed in these natural waterways.

The drainage system developed is not rain specific. It is meant for disposal of excess irrigation water and rain water disposal is for very meager amount. Thus rain water disposal is a side benefit of drainage system.

The type of rainfall deluge we are having now requires us to activate these old drainage routes. The main waterways are Dhoro Puran, Sohni Dhoro, Hakro Dhoro and Dhoro Naro.

RECOMMENDATIONS :

Short term and long term measures should be taken. Short term measures mean actions to be taken before next rainy season. Long term measures mean actions to be taken beyond next rainy season.

SHORT TERM MEASURES

i. Drainage system should be revamped

ii. Contingency plan should be prepared by SIDA and Irrigation Department

iii. Agency to implement the plan should be identified

iv. Agency identified should be given authority and funds to implement the plan.

LONG TERM PLANS

i. Present drainage system should be augmented to face present rainfall deluge.

ii. Blocked natural drainage routes should be reactivated

iii. Drainage cover should be provided to areas where there is no drainage system.

Paper : **Disastrous Effects of Rain 2011 in Sindh, Pakistan**

Author : ***Dr. Bakhshal Khan Lashari and Zarif Iqbal Khero***

Recommendations :

Conclusions :

Due to climate change and monsoon shift pattern the 2011 rainfall in Sindh started from mid-August to September; though monsoon period is July-September, which disrupted half of the area of Sindh Province. The damages to life, property and livelihood including agriculture and livestock were beyond the capacity of the people.

- The rains 2011 devastated mainly left side districts of lower Indus Basin. Tharparker, Badin, Shaheed Benazirabad, Mirpurkhas, Tando Mohammad Khan, TandoAllahyar, Badin and Khairpur of Sindh province;
- An estimated approximately 500 civilians lost their lives, about 5.3 million people affected, 1.2 million houses damaged (partially/fully) and 1.6 million cropped area damaged; and

- The 2011 flood not only caused heavy damages, but also exposed the shortcomings of existing drainage system on the left bank of river Indus in Sindh Province.

The left side of the lower Indus Basin (Sukkur to Sea) consists of: Left Bank Outfall Drain (LBOD-which covers districts Benazirabad, Sanghar, Mirpurkhas and Badin) and Kotri Surface Drainage System. The capacity of these drains is to drain out runoff of only 50 mm rain water whereas the rain 2011 was above average 500 mm and the land gradient of the Sindh Province is flat. Due to insufficient and incapable drainage system, the following major problems were noticed.

- Timely flushing out of rain water from the agriculture land to disposal point and, therefore, large areas remained uncultivated for the Rabi season;
- Overtopping and breaches on most of the surface drainage system;
- Poor maintenance of drainage system and blockage (encroachment) of natural waterways by local community caused slow evacuation of rain water. Consequently, it aggravated the situation.

It is also concluded that more uneven distribution of monsoon rains and same or even more rainfall, but in shorter more intense bursts, like August 2010 and 2011 rain in the future may occur. Thus 'Rivers can't cope with all the water in such a short time. If similar type of floods comes in future – and that is uncertain – the flood misery for the people of Pakistan may be more. Thus, there is urgent need to look into the following suggestions.

SUGGESTIONS :

Basin Flood Management
This plan should be sustainable in terms of ecology, economically as well as technically. To protect life and property from flood risks and to enhance the capability of socio-economic development in the flood plains to realize the development vision in a basin through Integrated Flood Management (IFM)

Therefore, Basin flood management planning should reflect the overall vision and policy of IWRM with special attention on the management of floods. The policy has to be aligned to the water resources development and management.

Integrated Flood Management Plan
The integrated flood management plan should have close relationship between :

Water resource management, river management, land use management, forest management, erosion control, agriculture, Environment, Ecology, urban drainage and sewerage within a basin.

Therefore, flood management measures should take into account the entire basin from upstream to downstream.

Integrated Water Resources Management
Integrated water resources management is a systematic process for the sustainable development, allocation and monitoring of water resources use in the context of social, economic and environmental objectives. This promotes coordinated management of land and water, the river basin and upstream and downstream interests. Water resources are increasingly under pressure from population growth, economic activity an intensifying competition for the water among users. It also promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems. Thus, simultaneous consideration should be given to: watershed and water bodies;

Hydrology, hydraulics, environment, Surface and groundwater, Quantity and quality, policy and socio-economic, Multiple sectors, stakeholders and decision makers.

Paper : **Managing Floods in Pakistan: From Structural to Non-Structural Measures**

Author : ***Dr. AsadSarwarQureshi***

Recommendations :
Flooding has always been an issue in the Indus Basin. Monsoon rainfalls are the main source of floods in the basin. High flows are experienced in summer due to the increased rate of melt water and monsoon rains. The nature of flooding varies according to geography. Fluvial floods in the Indus plain prove most devastating, as the terrain is flat, densely populated and economically developed. Hill torrents (flash floods) are the second most destructive type of flood.

Projected climate changes are expected to increased variability of monsoon and winter rains and glacier melting which can increase the inter-annual and intra-annual variability of river flows resulting in serious floods in future. In order to be prepared for this situation, Pakistan needs to work on both structural and non-structural measures for flood protection. Pakistan must increase its storage capacity to mitigate the effects of super floods. The role of two major reservoirs Tarbela and Mangla in reducing peaks of floods during 2010 has been enormous. Construction of small dams can help in small scale irrigation schemes but would not be able to play their effective role in hydropower generation and flood management. In addition to these structural measures, we need to give equal emphasize on non-structural measures. We need to enhance our flood forecasting and flood warning capacity which is currently very weak. Restoration of existing wetlands, proper planning of urban development, improving preparedness and relief services and increasing coordination between different provincial and federal departments involved in water management and flood protection are few steps that can significantly improve our capacity to protect and manage floods in the country.

Paper : **Integration of Disaster Risk Reduction (DRR) into Water Sector**

Author : ***Ahmed Kamal***

Recommendations :
Pakistan's exposure to natural hazards and disasters could be ranked between moderate to severe. Natural hazards inducing avalanches, cyclones and storms droughts, earthquakes, epidemics, floods, glacial lake outburst floods (GLOFs), landslides, pest attacks, river erosion and tsunami pose risks to Pakistani society besides a variety of human induced hazards. Disasters have an enormous impact on development. A close analysis of the development process clearly argues for the need of systematic and more conscious ways of integrating disaster risk reduction (DRR) into development process. As such mainstreaming of DRR has been rightly prioritized in the Hyogo Framework for Action (HFA) adopted by 168 countries in January 2005 with Pakistan being one of the signatory countries.

Water related hazards are major features of natural disasters world-wide. Events like 1998-2002 droughts in Pakistan, 2004 floods in Bangladesh & Haiti and tsunami in Asia, unprecedented floods of 2007 in Pakistan and Southeast-Asia, historically unprecedented floods of 2010 in Pakistan, March 2011 tsunami in Japan, 2011 & 2012 climate change induced rains and floods in Sindh & Balochistan drew significant international attention. According to Intergovernmental Panel on Climate Change, global temperature increased by 0.6 C over the last century and is forecast to rise by further 1.4-5.8 C before the end of this century. The harmful effects of global warming are already being manifested around the world in the form of extreme weather events such as storms, tornadoes, floods, droughts, biodiversity loss, rise in sea level, food insecurity and lot more.

Some of the main underlying causes of vulnerability to water-related disasters which are integrally linked and mutually reinforcing include : Poverty, Unplanned urbanization,

Environmental degradation, Fragmented institutional structures and Imbalance between prevention & response resources. According to the World Water Development Report Water for people, Water for life (WWAP, 2003), the traditional sectorial planning approach of the water sector has limited the capacity for effective integration of disaster risk reduction concerns. In line with above there seems a dire need of integration and mainstreaming of DRR into water sector development process in Pakistan for sustainable water resources development and management through strategic plan for core areas in the water sector. Salient recommendations to implement this strategic DRR mainstreaming plan in prioritized areas in water sector are given here.

For Flood Control :

- Priority to areas of potentially higher economic flood hazard or human suffering;
- Flood risk management policies through National Flood Protection Plans under integrated approach;
- Based on review of existing design criteria, standardization of designs and specifications for Flood Protection Works duly incorporating DRR aspects even moving away from traditional approaches;
- Flood Risk Assessment of selected on-going flood protection projects;
- Preparation of a program for inbuilt DRR aspects in future Flood Control and Protection measures;
- Flood retardation through multiple storages, flood embankments and adequate O &M of infrastructure;
- Up-dation of flood operation manuals of dams, refinement and further development & improvement of flood flow/rainfall computer model for Indus River System;
- Defining the Extent of Flood Plains;
- Weather radars network and other flood monitoring system for enhancing flood forecasting capabilities, especially for River Kabul and remote areas of Sindh/ Balochistan, Gilgit-Baltistan as a priority;
- Effective GLOFs monitoring system in GB;
- Flash Floods Monitoring & Warning System for hilly areas of upper Punjab, KP, AJ&K and Gilgit.
- Local flood warning dissemination system;

For Water Resources Development :

- Construction of large storage dams/reservoirs to ensure water availability for irrigation, power generation etc;
- Augmentation of existing storages along with more small and medium dams to meet ever increasing water requirements at national scale;
- Improvement of water conveyance infrastructure including modernization of barrages, system improvement through remodeling, rehabilitation and lining of canals and water courses (where ground water is brackish);
- Improvement in drainage & reclamation system;
- Improve overall irrigation efficiency from 40% at present to 45% in (20-25 years) to save about 6 MAF of water;

- A comprehensive strongly coordinated legal & administrative system to address planning, environmental protection & water resource management and consolidation of existing legislation into a manageable number of concise but comprehensive Acts;
- Strict monitoring & quality control of river training/flood control, drought mitigation, irrigation/water supply, dams' safety projects.

For Drought Mitigation :

- Floodwater storage for groundwater recharge;
- Adoption of excavated large water pits in the foothills/mountainous plains (before commencement of monsoon season);
- Retention of rain/floodwaters in green belts in cities, natural depressions in suburban/rural areas as a means of water conservation;
- Application of retarding basin techniques in plain areas;
- Rainwater harvesting of watersheds of hill torrents and small streams;
- Rain water harvesting for household and agricultural uses;
- Watershed management to reduce degradation of upper catchments for runoff moderation and sedimentation minimization;
- Adopting drought tolerant crops and cropping patterns based on experience of regional countries;
- Farmers motivation to use innovative IWRM techniques in non-irrigated areas for rain / flood water preservation;
- Experiment rainwater harvesting by compaction and shaping of slopes of stabilized dunes as natural catchments and interdunal valleys as cultivated areas.

For Dams & Barrages :

- Proper set up for continuous Dam Break Study, Sub-Basin Hydrological Studies and Flood Routing Studies;
- Measures to improve the condition, safety & security status of existing dams barrages, assessment of existing dam & barrages safety assurance measures;
- Implement a long term program on dams and barrages safety improvement in Pakistan;
- Agreed road map and action plan (program) for reforming and strengthening of dam & barrages safety setup and improvement of dam safety assurance in Pakistan;.
- Dams & barrage registry information management system for a modern regulatory system for dam & barrage safety assurance to also include key attributes (i.e. physical characteristics, age, condition, purpose, and links to relevant documentation);

Strengthening Institutional Arrangements :

- Strengthening appropriate legal frameworks to address integrated flood management, drought mitigation, dam safety assurance based on risk management strategies;
- Informed decision making based on sound scientific knowledge, as well as local, indigenous knowledge;

- Information base to support planning and a pro-active response to disaster mitigation and reduction;
- Representative range of stakeholders in the Water Sector DRR mainstreaming decision making process;
- Regional strategies and cooperation arrangements where rivers span two or more national boundaries;
- Partnerships among different levels of Government, civil society, private sector groups and communities;
- Decentralized decision-making through local authorities and basin communities;
- Effective policies to regulate future growth of human settlements in risky areas;
- Placement of a model Decision Support System (DSS) to effectively depict the future disaster mitigation policy;
- Pursue overall Human Resource Development in the Flood & Drought Management, Dam Safety & Security.

Paper : **Pakistan Proposed Approach to Flood Control and Management Based on 2010 Experience**

Author : ***Riaz Nazir Tarar***

Recommendations:

Improving flood management in Pakistan

i. The flood management in Pakistan needs an integrated system catering for all pre-flood, during the flood, and post-flood requirements.

ii. Water storages, both on-channel and off-channel, have to be built to attenuate the flood peaks.

iii. The flood warning and forecasting systems all over the country need extension and improvement. The capacity building both in terms of equipment (weather radars), softwares and human resources need immediate attention.

iv. All river works; especially flood protection works and barrages should be given due importance and priority in resource allocation, irrespective of flood frequency. All the flood bunds in the country should be redesigned to meet the latest requirements.

v. New bund systems should be planned on holistic requirements.

vi. The riverine/khadir (active flood plain) areas need better regulation and a proper enforcement mechanism for planned use in due consideration of flooding risks.

vii. Regular updating of the Standard Operating Systems (SOPs), drills the disaster management, capacity building and training of managers for flood protection, barrage management, and relief works, need immediate positive attention.

viii. All the known flood routes drainage systems should be kept in good order and new ones identified.

ix. The general public must be kept duly informed on all aspects of floods and their risks along with managing positive role of the media.

x. Only properly qualified, well trained and dedicated staff should be entrusted with the charge of barrages and flood works.

xi. Better inter-provincial coordination is needed for embankments and channels which serve more than one province.

xii. The Federal Flood Commission (FCC) presently has a limited role. This role needs to be enhanced along with expansion of the organization. The idea of conversion of the FCC into a Federal Flood Control Authority (FFCA) needs serious consideration. This authority if created should have proper in depth coordination with provincial flood and barrage management organizations.

xiii. People living in flood prone areas need to be educated and trained in negotiating with the floods and steps to be taken, before, during and after each flood wave. They must be kept fully informed as the flood events develop.

SYMPOSIUM ON "EMERGING PHENOMENON OF UNTIMELY RAINS / FLOODS 2011 IN PAKISTAN" DATED JANUARY 02, 2013

Recommendations by Pakistan Engineering Congress for Flood Control and Rain Effects Management for consideration by the Federal Government of Pakistan

1. The flood management in Pakistan needs an integrated system catering for all pre-flood, during the flood, and post-flood requirements.

2. Water storages, both on-channel and off-channel, have to be built to attenuate the flood peaks.

3. The flood warning and forecasting systems all over the country need extension and improvement. The capacity building both in terms of equipment (weather radars), softwares and human resources need immediate attention.

4. All river works; especially flood protection works and barrages should be given due importance and priority in resource allocation, irrespective of flood frequency. All the existing flood bunds in the country should be evaluated for safety and redesigned to meet the latest requirements.

5. New bund systems should be planned on holistic requirements.

6. The riverine / khadir (active flood plain) areas need better regulation and a proper enforcement mechanism for planned use in due consideration of flooding risks.

7. Regular updating of the Standard Operating Systems (SOPs), drills for disaster management, capacity building and training of managers for flood protection, barrage management, and relief works, need immediate attention.

8. All the known flood routes and drainage systems should be kept in good order clear of encroachments and additional ones added.

9. The general public must be kept fully informed on all aspects of floods and their risks knowledge about safe spots and mode of shifting alongwith managing positive role of the media.

10. Only properly qualified, well trained and dedicated staff should be entrusted with the charge of barrages and flood works.

11. Better inter-provincial coordination is needed for embankments and channels which serve more than one province.

12. The Federal Flood Commission (FCC) presently has a limited role. This role needs to be enhanced along with expansion of the organization. The idea of conversion of the FCC into a Federal Flood Control Authority (FFCA) or a National Water Commission needs serious consideration. This authority if created should have proper in depth coordination with provincial flood and barrage management organizations, and assume a role similar to FEMA of USA.

13. People living in flood prone areas need to be educated and trained in emulating with the floods and steps to be taken, before, during and after each flood event. They must be kept fully informed as the flood events develop.

14. Priority be given to areas of potentially higher economic flood hazard or human suffering.

15. Based on review of existing design criteria, standardization of designs and specifications for Flood Protection Works duly incorporating Disaster Risk Reduction (DRR) aspects even moving away from traditional approaches.

16. Defining the extent of Flood Plains.

17. Weather radars network and other flood monitoring system for enhancing flood forecasting capabilities, especially for River Kabul and remote areas of Sindh / Balochistan, Gilgit-Baltistan are needed as a priority.

18. Flash Floods Monitoring & Warning System for hilly areas of upper Punjab, KP, AJ&K and Gilgit-Baltistan may be put in place.

19. Local flood warning dissemination system must be developed and put in place.

20. Construction of an independent natural escape network wherever feasible may be constructed.

21. Identification of natural depressions, their strengthening for enhancing their storage capacities and identification of accessible high elevation areas for settlement of rain/flood affectees in future floods.

22. Flood plan zoning in rain / flood / prone areas should be carried out in order to identify flood risk areas i.e. cities, towns, and villages, industrial areas etc. and proper drainage system of all main cities/towns should be designed so as to avoid such urban flood situation in future.

23. New settlements / abadies should not be allowed to settle in future in low lying area/depressions or flooding routes. For the existing abadies proper protective measures based upon detailed investigations / surveys may be adopted.

24. Proper pumping system should be installed for the existing urban areas, where gravity drainage is ineffective.

25. In view of the changing climate, flood management plans need to be formulated at district level clearly indicating the safe high grounds marked for immediate evacuation during the disaster and for establishment of flood relief camps. These plans must be well prepared and shared with all concerned organizations. General public awareness about flood adaptability and preventive measures may be propagated as a regular feature before every flood season.

26. The issue of urban flooding caused due to poor drainage needs to be seriously dealt by district level authorities in collaboration with the concerned irrigation departments.

IMPORTANCE OF WATER BOUND MACADAM AND ITS QUALITY CONTROL FOR HIGHWAYS AND HEAVY TRAFFIC ROADS IN PAKISTAN

By

Shamim Zafar[1] and Mahmood A. Malik[2]

ABSTRACT

The need for use of water bound macadam in place of aggregate base course is growing day by day. Water Bound Macadam (WBM) had proved a better material in both quality & cost parameters. To cope with the requirement of construction new methods for compaction tests both for laboratory and field are required.

The physical properties and strength perimeters of aggregate used in WBM i.e. abrasion, soundness and specific gravity are well within specified limits when tested as per American Association of State Highway and Transportation Officials (ASSHTO) T 96, T 104 and T 85 respectively. Due to the size and percentage of aggregate used in Water Bound Macadam (WBM) certain modifications are required for determination of density for WBM both in field and in laboratory.

INTRODUCTION

With an increase in heavy traffic the need for improvement of pavement structure is also gaining momentum. Pakistan is a victim of road failures in the form of rutting, fatigue cracking and complete deformation of pavement structure. Rutting is related to asphalt failure but fatigue cracking and deformation are results of failure of layers underlying the bituminous layers.

The pavement layers below bituminous surfacing comprise the following:

- Aggregate Base Course/Water Bound Macadam
- Subbase Course
- Subgrade

The aggregate layer immediately below the bituminous surfacing provides support and drainage. The load carrying capability of the aggregate layer is critical in road design and performance. The aggregates used in this layer must be strong enough, and compacted to the required density to hold the load of heavy traffic.

In Pakistan Aggregate Base Course (ABC) is being used as the layer just below the bituminous layer since decades. ABC consist of dense graded material comprising aggregate ranging in size from 50 mm to 0.075 mm. Due to the lack of coarse aggregate, problem of segregation and improper mixing at site, ABC seems to cease the properties of stable base, so cannot resist the heavy traffic loads and sometimes deform within a very short span of time.

To overcome this difficulty, ABC is replaced by Water Bound Macadam (WBM) by many executing agencies. WBM consists of two components, a relatively single sized stone with specified nominal maximum size and well graded fine aggregate which passes 5mm sieve and normally stone dust is used for the purpose. The percentage of coarse aggregate and stone dust is generally kept at 70/30. The main advantage in WBM layer is a stone on stone contact which gives a better resistance against the forces applied by the load of heavy traffic.

Unfortunately an appropriate method has not been established up till now to control the quality of work for WBM both in field and in laboratory. This paper works out method which will help to control the quality of work for WBM both in laboratory and field.

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OBJECTIVES :

The main objectives of the paper are:

- To establish a method for determination of laboratory density/specific gravity of WBM without disturbing the original structure and size of aggregates.
- To determine stone on stone contact and to establish a percentage of coarse and fine aggregate in WBM material.
- To recommend a percentage of laboratory density for determination of compaction of WBM material at site.

BRIEF BACKGROUND:

The ability of the road to carry load depends on its strength, which in turn depends on the type of materials and strength of soil beneath it. The majority of the roads are constructed with relatively thin asphalt surfacing and generally A-2-4 or A-4 soil is used in construction of embankment and subgrade. In these circumstances the aggregate layer just below the bituminous layer must be robust and sturdy to sustain the load of heavy traffic.

In Pakistan, ABC is being used as the layer underlying the bituminous layers. The aggregate base not only provides support and drainage but its load bearing capacity is also critical in road design and performance. The material used for ABC must be tough, strong and compacted to the specified density to give it the required strength.

The gradation and material properties specified for ABC by different agencies are as follows:

GRADING REQUIREMENTS FOR AGGREGATE BASE MATERIAL

Sieve Sizes (mm)	PASSING PERCENTAGE			
	AASHTO M 147	ASTM D 1241B	NHA	MOC (KSA)
50.0	100	100	100	100
25.0	75~95	75~95	70~95	55~85
19.0	-	-	-	50~80
9.5	40~75	45~75	30~65	-
4.75	30~60	30~60	25~55	35~60
2.00	20~45	20~45	15~40	
0.425	15~30	15~30	8~20	10~25
0.075	5~20	5~15	2~8	3~10

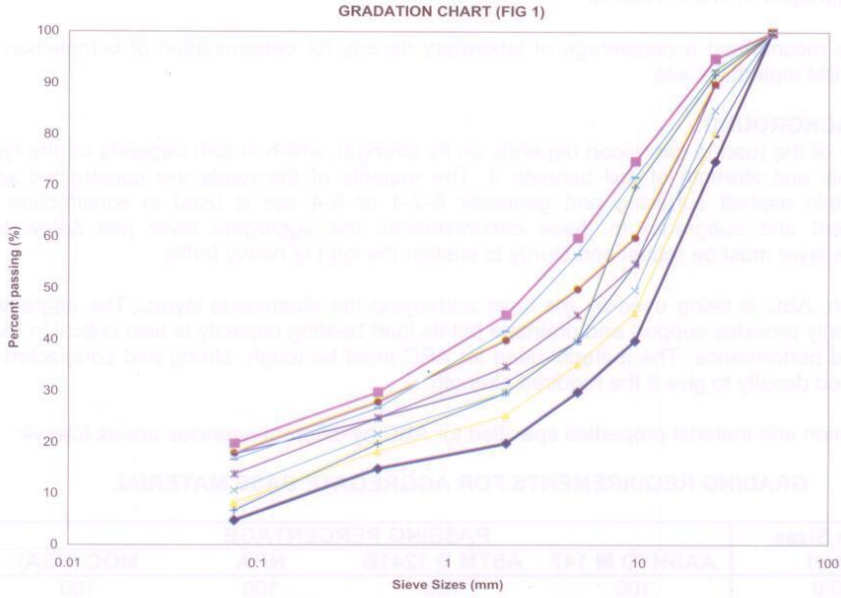
MATERIAL PROPERTIES:

PROPERTIES	AASHTO	ASTM	NHA	MOC (KSA)
CBR	-	-	80 %	100%
LOS ANGELES ABRASION	50% (max)	50% (max)	40% (max)	40% (max)
SOUNDNESS	-	-	12% (max)	12% (max)
FLAKINESS INDEX	-	-	15% (max)	-
LIQUID LIMIT	25% (max)	25% (max)	25% (max)	25% (max)
PLASTICITY INDEX	6% (max)	6% (max)	6% (max)	6% (max)

It is obvious from the gradation table that maximum retained percentages as per AASHTO / American Society for Testing and Materials (ASTM) and MOC (KSA) at sieve size 25mm are 25% and 45% respectively. This means that overall percentage of coarse aggregates is very low. Further more these gradations do not support the concept of stone on stone contact due to lower percentage of coarse aggregates. It is now a well documented that coarse aggregates have the maximum capability to withstand the heavy traffic load.

The type of material used in ABC is difficult to handle and segregation of material from coarser to finer and from finer to coarser aggregate is a common phenomenon observed at site. CBR is

considered as one of the important parameters in road designing. As per Figure-1 there are many possibilities for gradation of ABC, and it is also a fact that with the variation in gradation, CBR values also varies. The CBR at extreme finer and extreme coarser gradation but within the specified envelope will give low CBR value than at well graded and dense gradation. One of the reasons for failure of ABC under heavy traffic is the low CBR value due to variation in gradation.



ADVANTAGES OF WATER BOUND MACADAM:

To cope with the failure, Punjab Highway Department successfully used WBM in place of ABC. National Highway Authority (NHA) has also included WBM in its specifications. WBM layer consists of a stone skeleton of which the voids are filled with fine material. The stone skeleton, because of its single size, has large amount of voids but has high shear strength. If confined properly the stone skeleton forms the backbone of macadam and is largely responsible for the strength of the compacted layer. The large aggregate provides the bearing strength of WBM and fine aggregate provides stability to the material.

The gradation and material properties specified for WBM by different agencies are as follows:

GRADING REQUIREMENTS FOR WATER BOUND MACADAM

Sieve Size (mm)	AASHTO M 43 / ASTM D 448			NHA SPECIFICATIONS		
100	100	-	-	100	-	-
90	90~100	-	-	90~100	-	-
75	-	100	-	-	100	-
63	25~60	90~100	100	25~60	90~100	100
50	-	35~70	90~100	-	35~70	90~100
37.5	0~15	0~15	35~70	0~15	0~15	35~70
25	-	-	0~15	-	-	0~15
19	0~5	0~5	-	0~5	0~5	0~5
12.5	-	-	0~5	-	-	-

MATERIAL PROPERTIES:

PROPERTIES	NHA
COARSE AGGREGATE	
LOS ANGELES	45% (max)
SOUNDNESS	12% (max)
FLAKINESS INDEX	15% (max)
FINE AGGREGATE	
LIQUID LIMIT	25% (max)
PLASTICITY INDEX	6% (max)

The properties of both ABC and WBM are the same except for size of aggregate and gradation. The larger sized aggregates and stone on stone contact is the main criteria for better performance of WBM than ABC.

Stone on stone contact in WBM is of prime importance as stones are the main load carrying component. This stone-on-stone contact is only possible in an aggregate structure as found in WBM and is seldom observed in dense graded material where the coarse aggregate seems to be floating within the fine material with no stone-on-stone contact. Due to stone on stone contact WBM is a far better option than aggregate base course for highways and heavy traffic roads in Pakistan.

Potgieter, Hattingh and Schultz (1997) describe following four stages to achieve densification and compaction of WBM:

- **Loose:** Coarse aggregate is spread in loose throughout the width and length of the pavement.

- **Orientation:** The orientation of large aggregates is adjusted to achieve an optimum packing pattern by light rolling.

- **Interlocking:** The large aggregate are locked into an optimum packing pattern. According to Potgieter, Hattingh and Schultz, this is the highest level of densification that can be achieved during construction by using heavy rollers.

- **Densification:** The air voids in the layer are minimized through the optimum packing pattern of coarse and fine aggregates and this can be best achieved under traffic loading. In other words WBM layer can achieve best compaction and densification with tire rollers or loaded dump trucks.

The density of WBM is the single most important factor responsible for the performance of this material and no compromise should be made on the density specification of WBM for its durability.

QUALITY CONTROL OF WATER BOUND MACADAM (WBM):

Irrespective of the better quality of roads and highways constructed by using WBM, the quality control method for WBM is still unclear as no standard method is present for determination of laboratory density for the same.

There is no explicit method provided in AASHTO for determination of laboratory density of WBM. The present method as per AASHTO T 180 is not an appropriate method for determination of laboratory density for aggregate sizes in excess of 19 mm without any correction. The correction for coarse aggregate as per AASHTO T 224 for adjustment in field dry density is also limited to a maximum of 30%. In contrast WBM has 65% to 70% aggregate retained on 19mm sieve, so the correction of coarse particles does not apply.

As WBM is becoming essentially important for highways and heavy traffic roads in Pakistan, it is of utmost importance to work out a method for determining the laboratory density without disturbing the size of aggregate structure as present in WBM.

Keeping in view the importance of WBM and the difficulty in obtaining the laboratory density due to size and percentage of coarse aggregates following tests were carried out which can be helpful to control the quality of work at site.

- Determination of Maximum Specific Gravity/Density of WBM aggregates as per ASTM D 2041 by varying the percentage of coarse and fine aggregates.

- Determination of stone on stone contact by calculating the voids in coarse aggregates in dry rodded condition as per ASTM C 29/C 29M and compared with voids in coarse aggregate in the compacted layer.

- Determination of Field density (compaction) as per AASHTO T 191 modifying the diameter of base plate and cone to 8 inches or 12 inches.

TEST METHOD ASTM D 2041:

Summary of Test Method

The method covers the determination of theoretical maximum specific gravity and density of the uncompacted mixture of coarse and fine aggregate.

The test procedure follows that:

- The vacuum container specified in Type 'F' of the test method is an appropriate container for the test.

- Calibrate the container by accurately determining the mass of water required to fill it over different ranges of temperatures.

- A weigh sample of oven dry coarse and fine aggregates of WBM in the proportion used during construction in loose state is placed in a vacuum container. (10 kg. sample will be an appropriate quantity for the test)

- Sufficient water at a temperature of 25 $\pm$ 1 °C is added to completely submerge the sample.

- Vacuum is applied to gradually reach the residual pressure in the vacuum vessel at 30mm of Hg or less. This residual pressure is maintained for 15 minutes, during this period the container and the content is agitated to remove any entrapped air within the aggregate particles.

- At the end of the vacuum period, the vacuum is gradually released.

- The volume of the sample is obtained by filling the vacuum container level full of water and weighing in air.

- The theoretical maximum specific gravity of the sample is calculated as follows:

$$A/A+D-C$$

Where A= mass of oven dry sample in air (gms)

D = mass of container filled water at ° C (gms.)

E = mass of container filled with sample and water at ° C (gms)

The theoretical maximum specific gravities and densities of the aggregate mixture will depend on the composition and specific gravities of coarse and fine aggregates present in the mixture.

FIELD DENSITY TEST:
The field density tests to determine the compaction of WBM are then carried out according to AASHTO Method T-191 but with 8" or 12" sand cone apparatus. The moisture content is calculated in accordance with AASHTO T 224 (2001 or latest edition) and the dry density thus obtained shall be compared with the specific gravity/density already determined as per ASTM D 2041. The field dry density should not be less than 90% of the specific gravity/density obtained as per ASTM D 2041.

STONE ON STONE CONTACT:
The stone on stone contact can be determined by calculating the voids in coarse aggregates in dry rodded condition (ASTM C 29/C 29M) and compared with voids in coarse aggregate in the compacted layer. Studies carried out in this regard for Stone Matrix Asphalt (SMA) had shown that coarse aggregates in dry rodded condition in the absence of fine aggregates represent a stone skeleton as there is nothing to hold the aggregates apart. Lesser percentage of VCA in compacted layer (VCA_{layer}) as compared to VCA in dry rodded condition (VCA_{DRC}) will suggest that coarse aggregate particles are still in contact with one another and have not been pushed apart by fine aggregates. The procedure is adopted for Stone Matrix Asphalt (SMA) in AASHTO PP 41.

CONCLUSION:
The work carried out in laboratory with the limited sources reveals the following:

- The best suited percentage for coarse and fine aggregates for WBM is in the range of 75/25 and 65/35. (Table 1)
- Below 65% of coarse aggregate the $VCA_{(Comp.\ Layer)}$ is more than $VCA_{(DRC)}$ which means stone on stone contact is either very weak or absent. (Table 1)
- The field dry density as per test method "AASHTO T 191" but with 8 inch diameter cone and base plate was in the range of 2.40 g/cc to 2.43 g/cc and coarse aggregate in the range of 68% to 72% (Table 2).
- The field density is 89% to 90% of the Maximum Specific Gravity achieved as per test method "ASTM D 2041".

RECOMMENDATIONS:
Keeping in view the importance of WBM in construction of highways and heavy traffic roads and the difficulties faced in controlling the quality of work due to lack of appropriate testing method, it is recommended that:

- Test Method as per ASTM D 2041 be used for determination of Maximum Specific Gravity/Density for WBM material without compromising on actual size of aggregates.
- Determination of voids in dry rodded condition as per ASTM C 29/C29M and in compacted layer shall be included in the quality control to ensure stone on stone contact.
- The compaction of WBM layer shall be checked at 90% of the Maximum Specific Gravity/Density achieved in laboratory as per Method ASTM D 2041.

Further studies can be carried out on the ongoing projects for verification and improvements of the test methods.

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- *General Specifications NHA, 1998.*
- *General Specifications, KOS, MOTC.*

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- *AASHTO M 43, ASTM D 448.*
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MAXIMUM SPECIFIC GRAVITY FOR WATER BOUND MACADAM AGGREGATE								
Percent Coarse and Fine Aggregates		80/20	75/25	70/30	60/40			
Wt. of Oven Dry Sample	gms	5002	5002	5000	5000			
Wt. of Container + Water	gms	11590	11590	11590	11590			
Wt. of Container + Water + Sample	gms	14728.5	14734.0	14745	14748.0			
Volume	cc	1863.5	1858	1845	1842			
Maximum Specific Gravity	Gmm	2.684	2.692	2.710	2.714			
Apparent Specific Gravity								
VOIDS CALCULATIONS								
$VCA_{(DRC)}$								
A) Oven Dry Sp.Gr. of C. Aggregates		2.628						
B) Dry Unit Wt. of C. Aggregates		1.488						
C) Sp. Gr. of Water		1						
$VCA_{(DRC)}$ =((A*C-B)/(A*C))*100		43.38						
$VCA_{(Comp. Layer)}$								
A) Dry Field Density of WBM @ 90% of Gmm.		2.416	2.423	2.439	2.443			
B) Oven Dry Sp.Gr. of C. Aggregates		2.669	2.669	2.669	2.669			
C) Percent C. Aggregates in WBM		80	75	70	60			
$VCA_{(Comp. Layer)}$ = 100-(A/B)C		27.59	31.91	36.03	45.08			

VCA = Voids in Coarse Aggregate
DRC = Dry Rodded Condition
Comp. Layer = Compacted layer

MAXIMUM SPECIFIC GRAVITY FOR WATER BOUND MACADAM AGGREGATE							
Percent Coarse and Fine Aggregates		80/20	75/25	70/30	65/35	60/40	50/50
Wt. of Oven Dry Sample	gms	5002	5002	5000	5000	5000	5000
Wt. of Container + Water	gms	11590	11590	11590	11590	11590	11590
Wt. of Container + Water + Sample	gms	14736.5	14739.0	14741.5	14742.0	14745.0	14735.0
Volume	cc	1855.5	1853	1848.5	1848	1845	1855
Maximum Specific Gravity	Gmm	2.696	2.699	2.705	2.706	2.710	2.695
Apparent Specific Gravity (Calculated)		2.703	2.704	2.705	2.706	2.707	2.709
		80	75	70	65	60	50
VOIDS CALCULATIONS							
$VCA_{(DRC)}$							
A) Oven Dry Sp.Gr. of C. Aggregates		2.669					
B) Dry Unit Wt. of C. Aggregates		1.495					
C) Sp. Gr. of Water		1					
$VCA_{(DRC)}=((A*C-B)/(A*C))*100$		43.99					
$VCA_{(Comp. Layer)}$							
A) Dry Field Density of WBM @ 90% of Gmm.		2.426	2.429	2.434	2.435	2.439	2.426
B) Oven Dry Sp.Gr. of C. Aggregates		2.669	2.669	2.669	2.669	2.669	2.669
C) Percent C. Aggregates in WBM		80	75	70	65	60	55
$VCA_{(Comp. Layer)} = 100-(A/B)C$		27.28	31.73	36.15	40.70	45.17	50.01

VCA = Voids in Coarse Aggregate
DRC = Dry Rodded Condition
Comp. Layer = Compacted layer

SOLID WASTE MANAGEMENT IN PAKISTAN : CURRENT PRACTICES AND FUTURE PERSPECTIVE

By

Dr. Asad Sarwar Qureshi[1]

Abstract

This paper reviews the current situation of solid waste management in Pakistan. The solid waste generation in Pakistan ranges from 0.6-0.8 tons capita per day with an average growth rate of 2.4% per year. About 40-50 percent of the total waste remains either at the collection point or in streets. Dumping or landfill sites are not designed properly causing problems like incomplete decomposition, methane production and leachate contamination of groundwater. About 250,000 tons of medical waste is annually produced from all sorts of health care facilities in the country. Disposable needles, syringes and other medical items are a potential source of hazardous waste material. The large quantities of obsolete pesticides (1000 to 3000 tons) are another source of pollution and threat to environment.

Municipalities are not doing any type of recycling activity. The recyclable material is usually separated by people themselves and then sold to street hawkers. The amount of recyclable material varies from 23,000 tons/year for Quetta to over 500,000 tons/year for Karachi. These recyclable materials can generate huge income for city district governments if properly managed. Although composting is recommended for solid waste management, its operational efficiency is still questionable. The guidelines for integrated management of solid waste drafted by Pakistan Environmental Protection Agency (PEPA) are rarely followed. Implementation of these guidelines depends on the financial and technical facilities available with the concerned municipalities and the level of safety required.

Key words: *solid waste management, municipalities, hazardous waste, environment, Pakistan*

1. INTRODUCTION

Pakistan is currently the most urbanized country in South Asia. The urban growth rate is almost twice the rate of overall population. The population growth rate averaged around 2.5% per year for rural areas and around 3.5% per year for urban areas. This is because of large scale migration from rural areas to cities in search of better living, health and educational facilities. From 2005 onward, the urban population is expected to grow exponentially and is expected that by 2030, urban population will become 50% of the total population of 260 million.

The rapid transition of urban population could contribute positively in the pace of country's economic development and poverty reduction if civil conditions permit. However, flip side of the coin is that availability of land and water resources is decreasing, existing infrastructure run down, quality of surface and groundwater is degrading. All these will hamper the economic development if necessary steps are not taken to match these facilities with the increasing population. The shortfalls in urban services are the result of constraints in resources, governance, institutional and financial arrangements. Poor water supply and sanitation conditions in most of the cities have serious impact on nation's health. World Bank Strategic Environmental Assessment for Pakistan (2007) estimates that the cost of health due to two water borne diseases i.e. diarrhea and typhoid will be Rs. 112 billion.

Municipal infrastructure in Pakistan is in a dismal state. Years of neglect and weakening of local government system could not keep pace in bringing Municipal facilities at par with the growing needs of the increasing population. Currently only 63% of the population has ready access to safe drinking water whereas only 53% in rural areas enjoy this facility. Access to sanitation is even worse where only 39% of the population has this facility. In rural areas, the population

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having access to proper sanitation is only 27%. Because sewerage and water supply lines are laid side by side in most parts of Pakistan, leakage is the main cause of water contamination.

Since the adoption of National Conservation Strategy (NCS) in 1992, Government of Pakistan (GoP) has made considerable progress in raising the public awareness of environmental issues. To further strengthen the implementation of NCS, the National Environmental Action Plan was approved by Government in 2001 and a new Environmental Policy was adopted in 2005, together with significant increase in the budget allocation for environmental management. Despite all these efforts, success has been limited. Environmental degradation is estimated to cost Pakistan at least 6% of the GDP, or about Rs. 365 billion per year. The most significant causes of environmental damage are water borne diseases due to inadequate water supply, sanitation and hygiene. This paper reviews the current practices of solid waste collection, disposal and treatment practices and provides recommendations for future waste management in Pakistan.

2. SOLID WASTE MANAGEMENT SITUATION IN PAKISTAN

Due to rapid increase in urban population, Municipal facilities such as drinking water, sanitation and solid waste management are coming under increasing pressure. Generation of solid waste is much faster than its collection and disposal capacity. Inadequate collection and disposal of waste poses serious health risk to the population and is the obvious cause of environmental degradation. Solid waste is disposed of in open dumps which produce a wide range of public health problems, creating breathing grounds for disease vectors such as rats, cockroaches, and flies. They are also a source of air pollution and surface and groundwater contamination. Disposal of untreated hospital waste and gas explosions present further hazards.

Inappropriate management of waster water and solid waste is one of the biggest issues so far as environmental degradation in Pakistan is concerned. Increasing population and migration to cities from rural areas is responsible for rapid urban expansion, much of it unplanned. As a result, waste generation process is much faster than existing collection and disposal capacity of most of the cities in Pakistan. This situation has further compounded the waste and liquid management problems. Many cities are now characterized as overcrowded with increasing problems of housing, contaminated water supplies and lack of proper sewage and waste disposal facilities which contribute to an unhealthy urban environment.

At present, proper solid waste management system right from collection to its proper disposal is almost non-existent in Pakistan. Solid waste collection by government agencies in most of the cities is only 50 percent of the total generation. However, for cities to be relatively clean, at least 75 percent of these quantities should be collected (PEPA, 2005). To achieve this target, proper planning and large scale capital investment is required. It is projected that as a consequence of population increase, waste generation in future will be increased by one to three percent per year. The increased quantity of waste will also place greater demand for disposal services. In the absence of adequate waste disposal methods, environmental problems will be exacerbated.

3. SOLID WASTE COLLECTION AND DISPOSAL-CURRENT PRACTICES

Most of the solid waste is collected in roadside bins and from here Municipal Corporation collects it infrequently. Solid waste generation ranges from 0.6-0.8 tons / c / day with an average growth rate of 2.4% per year. About 40-50 percent of the total waste remains either at the collection point or in streets. It is common practice to burn the waste in open. Household waste is usually collected and transported directly to a landfill site. However, these sites are not designed properly causing problems like incomplete decomposition, methane production and leachate contamination of groundwater. Therefore it is of paramount importance that the disposal sites are selected in locations which are accessible to public and to local regulatory agencies. Furthermore, proper operational procedures must also be followed.

At most of the collection points, different types of wastes are not collected separately. Waste is dumped un-segregated and collected by three methods i.e. hauled container system, stationary container system and bull carts. The hauled containers system is one in which containers loaded with waste are taken to the disposal site, emptied and brought back to the same site or

to the next site. In case of stationary container system, containers are emptied into vehicles therefore a number of containers can be emptied in one trip. These containers/vehicles are transported from one place to another with the help of tractor or trolley. These trolleys are usually overflowing as they are not properly covered. As a result, a sizeable amount of waste falls on the streets before it reaches to the landfill site.

The solid waste disposal in Pakistan is basically done through three different ways – landfill, size reduction and screening. Residential wastes are usually collected and transported directly to a landfill site. Most of the existing landfill sites are not properly designed and, therefore, create public health and environmental problems. Size reduction is a process in which collected waste materials are mechanically reduced in size. In practice, the terms shredding, grinding and milling are used interchangeably to describe mechanical size reduction. Screening is used to separate mixtures of materials of different sizes into two or more sizes by using screening surfaces. The separation practices are now well established and, as a result, quantities of wastes such as bottles, newspapers, plastic, food waste and aluminum cans are significantly reduced in the waste stream. Once these re-saleable waste components have been separated from waste they are considered to be raw material for many useful products. Details of different waste materials and their common reuse for various products are given in Table-1.

Table-1: Waste materials and their common reuse and recycling

Waste Material	Common Reuse and Recycling
Broken glass	Glass bottles
Bottles	Washed and used again
Bread	Livestock feed
Ferrous metal	Recycled in re-rolling mills
Newspapers and Papers	Various types of Packing and Cardboard etc.
Aluminum	Re-melt in moulds for various industries
Plastics	Uses / recycling of toys, shoe soles, shopping bags, sandals etc.
Plastic bags	Buckets and other household containers
Magazines, books etc.	Sold again at reduced prices
Old furniture	After repair sold again at reduced prices

4. TYPES, SOURCES AND COMPOSITION OF WASTE

Solid waste in Pakistan is generally composed of plastic, rubber, metal, paper, cardboard, textile waste, glass, food waste, animal waste, leaves and grass, bones, wood, stones and fines to various extents. These materials are generated from different sources as mentioned in Table-2.

Table-2: Sources of Solid Waste Generation

Source	Materials present
Offices	Corrugated boxes, lunchroom waste, office paper, wood pallets
Household	Appliances, newspaper, clothing, disposable, tableware, food packing cans, bottles, food scraps, yard trimming
Commercial building	Corrugated boxes, food wastes, paper, disposable tableware.
Institutions	Office paper, cafeteria and rest room waste, class room wastes yard trimming
Ferrous metals	Iron, steel, tin and metal cans
Non-ferrous metals	Primarily aluminum, aluminum cans, copper, brass and lead
Wood based industries	Lumber, wood products, pallets and furniture
Rubber based industry	Tyres, footwear, wire cords, gaskets
Textiles	Furniture, clothing and footwear
Miscellaneous	Other organic and inorganic materials including rock sand, dirt, ceramics, plaster, bones, ashes, etc.

Hazardous waste is any waste or combination of waste that poses a substantial danger, now or in future, to human, plants or animal life and which therefore cannot be handled or disposed of without special precautions. The hazardous solid waste is basically generated from six sectors i.e. agriculture, hospitals and clinical laboratories, small and large scale industry, commerce and household and obsolete pesticides.

According to WWF, around 250,000 tons of medical waste is annually produced from all sorts of health care facilities in the country. Disposable needles, syringes and other medical items that are released into the environment without proper steps to manage their disposal are also a potential source of hazardous waste material. There is no authenticated data about the amount of hazardous waste generated by different industries. The large quantities of obsolete pesticides (1000 to 3000 tons) are another source of pollution and threat to environment.

Industrial pollution is a big problem in Pakistan. Biggest contributors of industrial waste are petroleum and petro-chemical industries as well as pharmaceuticals, tanneries, textiles, pesticides, paint and dyes, fertilizers, inorganic chemicals and gender engineering industries. In addition, the post- consumer electronic equipment is also contributing to hazardous waste material. Most of the industries are reluctant to treat their wasted water and solid waste and do not adopt safe disposal procedures. Poor performance of this sector, lack of information about latest technologies and less respect for law are major reasons for this malpractice.

In Pakistan, there is no systematic mechanism for the collection and disposal of hazardous waste generated from hospitals, industries and agricultural activities. The collection and disposal of hazardous waste is mainly the responsibility of municipal corporations, which comes under the local Government and Rural Development. However, in practice, local governments usually collect and dispose large quantities of hazardous waste without any consistent standard procedures and often without any knowledge of their negative environmental consequences.

In any country, the amount of solid waste generated varies with the standard of living of its people. The composition of waste depends to a large extent on the affluence of the population contributing to the waste stream. It is essential to now the composition of waste, both at the source and at the disposal, to assess the most suitable option for disposal and recovery. For example, the feasibility of composting is determined by a combination of the quantities of waste generated and the proportion of organic waste, among other factors. The quantity and organic content is much lower in rural areas where many waste materials are traditionally used for feeding animals, agriculture and fuels.

Table-3 gives physical composition of waste in five major cities of Pakistan.

Table-3: Physical composition of waste (% by weight)

Items	Gujranwala	Faisalabad	Karachi	Peshawar	Quetta
Plastic and rubber	5.00	4.80	6.40	3.70	8.20
Metals	0.30	0.20	0.75	0.30	0.20
Paper	2.50	2.10	4.10	2.10	2.20
Cardboard	1.80	1.60	2.40	1.90	1.30
Rags	3.20	5.20	8.40	4.30	5.10
Glass	1.50	1.30	1.50	1.30	1.50
Bones	3.20	2.90	3.00	1.70	2.00
Food waste	14.70	17.20	21.00	13.80	14.30
Animal waste	1.00	0.80	3.00	7.50	1.70
Leaves, grass etc.	12.80	15.60	14.00	13.60	10.20
Wood	0.80	0.70	2.25	0.60	1.50
Fines	47.50	43.00	29.70	42.00	44.00
Stones	5.70	4.60	3.50	7.30	7.80
(Modified from EPMC, 1996)					

Table-3 reveals that there is a considerable content of plastic in the solid waste generated in Pakistan which is a cause of great concern. This can be a potential source of litter, emissions of hydrogen chlorides and dioxins from incinerators and contamination from chemical additives. Plastic can also be a direct threat to wildlife. Eliminating plastic bags can significantly improve the quality of compost and reduce the amount of waste that need disposal. Burning of plastics at the landfill is a common practice in Pakistan. Burning of plastics and chemical bath releases toxic substances and result in air pollution.

In Pakistan, hazardous hospital and industrial wastes are treated as ordinary waste which is dangerous for human health and environment. The Ministry of Health guidelines for hospital waste management are never implemented and hospital wastes are mixed with the municipal waste in collecting bins at roadsides and disposed of similarly. The respective municipalities despite spending 20% to 40% of their total budgets have not been able to dispose of hospital waste in a desirable environmentally safe manner.

5. TREATMENT AND DISPOSAL OF WASTE IN PAKISTAN

In Pakistan, solid waste is mainly collected by municipalities and there are large variations in the efficiency of waste collection ranging from zero percent in poor rural areas to over 90 percent in high income areas of large cities. In many large areas, waste collection and street sweeping is now subcontracted to any private companies. It is perceived that this action will improve the efficiency of waste collection. Collection rate of municipalities ranges from 50% to 70% of the total waste generated within their jurisdiction. The uncollected waste remains on streets, open spaces and vacant surrounding plots. These dumps are the permanent source of pollution and environmental degradation on continuous basis. The rate and amount of waste collected by five major cities of Pakistan is given in Table-4.

Table-4: Waste Collection in 5 major cities in Pakistan

Cities	Collection rate (%)	Daily collection (tons/day)	Annual total (tons/year)
Gujranwala	52	428	128,500
Faisalabad	54	499	149,737
Karachi	53	3419	1,025,550
Peshawar	61	494	148,102
Quetta	50	189	56,700

Treatment and disposal technologies such as sanitary land filling, composting and incineration are comparatively new in Pakistan. The first site for sanitary land filling is yet to be established. At present there are no landfill regulations or standards that provide a basis for compliance and monitoring (EPA-JICA, 2005). However, guidelines are being developed under the National Environmental Action Plan (NEAP).

Under the present system, municipalities are not doing any recycling activity. The recyclable material is separated by people themselves and then sold to street hawkers for recycling. The amount of recyclable material varies from 23,000 tons/year for Quetta to over 500,000 tons/year for Karachi (EPMS, 1996). These recyclable materials can generate huge income for city district governments if properly managed. Although composting is generally recommended for solid waste management, its operational efficiency is still questionable. The composting plants established in the private sector in most of the developing countries have failed due to poor design and subsequent failure to meet cost recovery expectations. The successful operation of these plants, greater urban demand and subsidies would be required. This will remain a challenge for most of the developing countries including Pakistan.

6. RECOMMENDATIONS FOR SOLID WASTE MANAGEMENT

In Pakistan, individuals dispose of wastes by throwing away plastic bags, wrappers, fruit peels, cigarettes, etc. in public places. Littering spreads pollution and ends up clogging drains and causing sanitation problems. In few cities, roadside dust bins have been introduced but the vague collection routines continue creating environmental problems. The hierarchy of integrated

waste management is given in Figure 1. For environment friendly disposal of solid waste, following guidelines needs to be followed.

- Municipalities should monitor the waste composition and waste bulk density annually. These two parameters are important for selecting garbage storage containers, public bins and collection vehicles and for estimating the total amount of collected waste.
- Municipalities with population of 500,000 should monitor moisture content and carbon-nitrogen ratio annually. Moisture content data is needed to decide about treatment options i.e. composting and incineration. Carbon-nitrogen ratio is used for composting.
- Municipalities having population of above 2,000,000 should also monitor Claorific value annually. This is essential for incineration.

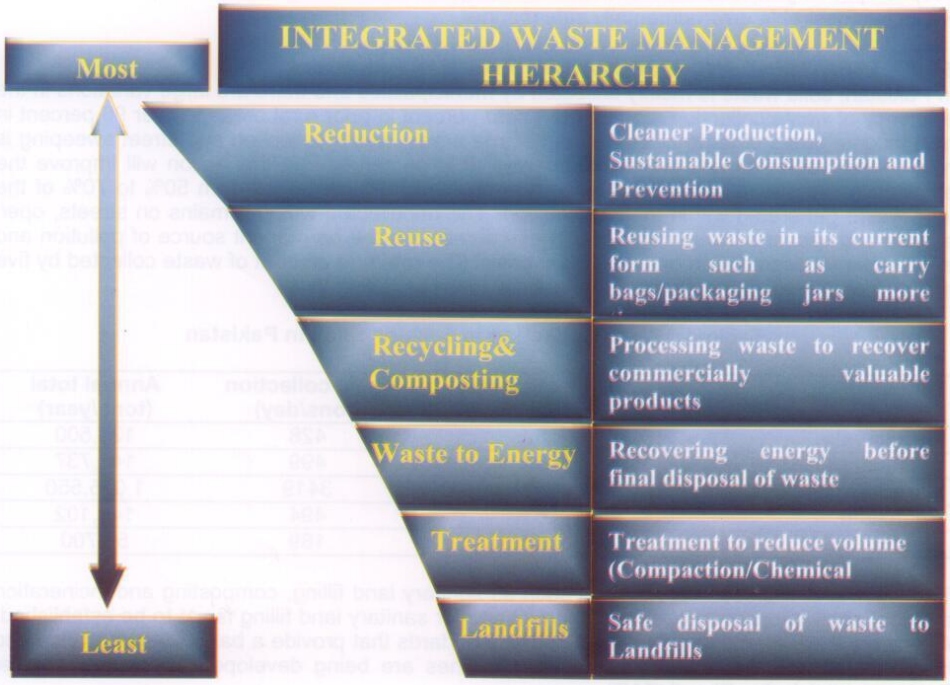

Figure 1: Integrated Waste Management Hierarchy

Waste Reduction (including Reuse and Recycling)

Waste reduction is important to minimize negative environmental impacts of solid waste and to reduce management cost. The first responsibility of waste reduction lies with the society who should follow the following steps:

- Limit your shopping—it saves money and availability of natural resources
- Avoid purchasing and using of disposable items
- Limit use of shopping bags – use cloth or paper bags
- Reuse the material

Waste Collection

There are no clear estimates of waste collection as most of the municipalities are without weighbridge on dumping sites. This is an important requirement for solid waste management, therefore, all municipalities should install weighbridges at their dumping sites.

Waste collection is generally separated into two parts, primary collection and secondary collection. Primary collection means waste transportation from the generating source (house, shop, factory, etc.) to the first dumping site. Secondary waste means transfer of disposal from dumping site to the first disposal or treatment site. The road/street sweeping waste is categorized as primary collection.

From proper management of solid waste, it is necessary that all municipalities monitor the collection / dumping amount at least once a year. All municipalities having population above 500,000 should install weighbridge in each of their disposal sites so that exact amount of waste collection can be estimated on regular basis.

Final Disposal

Final disposal site is usually not a place for reusable or recyclable material. There are many valuable waste that be recovered for financial benefits. For this reason these sites attract large number of scavengers and waste pickers. These valuable wastes must be separated from other waste before dumping into landfills. Some items decompose very quickly (i.e. kitchen items) whereas others take long time for decomposition (plastic and rubber takes over 100 years) and others are hazardous or toxic (i.e. batteries, lead, zinc and tube lights). After separating these materials, remaining waste can be deposited into different types of landfills. These include:

- Anaerobic landfill: *Waste is deposited in an excavated hole or natural depression.*
- Anaerobic sanitary landfill
- Improved anaerobic sanitary landfill
- Semi-aerobic sanitary landfill: *Leachate is collected in a leachate collection pond through properly sized perforated pipes embedded in graded boulders.*
- Aerobic (Sanitary) landfill: *In addition to leachate collection pipes, air pipes are constructed to pump air into the waste layers to maximize internal aerobic activity.*

For improving sanitary landfill systems, it is preferable first to determine the desired level of improvement. The level of improvement of sanitary landfill system can be achieved in four stages. The processes to achieve different levels of sanitary landfill system are given in Table 5.

- Level I: Controlled tipping
- Level II: Sanitary landfill with a bound and daily cover soil
- Level III: Sanitary landfill with leachate recirculation
- Level IV: Sanitary landfill with a leachate

Considering financial, technical and management capacities of local governments in Pakistan, it is recommended that municipalities of different sizes target different levels of achievements in sanitary landfill. These include the following:

- All municipalities should achieve target level I
- All municipalities above 500,000 should achieve target level II
- All municipalities above 2,000,000 should achieve target level III.

Table-5: Details of target levels I, II and III

Target	Level-I Introduction of controlled tipping	Level-II Sanitary landfill with a bound and daily cover soil	Level-III Sanitary landfill with leachate recirculation
Achieved level	• Establishment of access to site • Introduction of cover material to prevent fire, littering and odour. • Introduction of inspection control and operational records of incoming waste.	• Establish boundary and cover for waste disposal. • Introduce divider for unloading and working area. • Establish disposal site by constructing enclosed bunds. • Establish drainage system to divert storm water & seepage from surrounding areas. • Introduce buffer zone, litter control & gas venting facilities. • Introduce amenities for staff i.e. sanitary and locker rooms. • Introduce semi-aerobic sanitary landfill.	• Establishment of leachate control by the installation of leachate collection, recirculation and monitoring facilities.
Next level improvements	• Establish site boundary. • Introduction of environmental protection facilities. • Introduction of amenities for staff such as sanitary and lockers rooms. • Introduction of semi-aerobic sanitary landfill.	• Improve semi-aerobic sanitary landfill system. • Establishment of leachate control. • Establishment of leachate treatment.	• Introduction of leachate treatment system and semi-aerobic sanitary landfill.
Environmental Issues	• Surface and groundwater pollution by leachate. • Littering and dust • Breeding of insects and rodents. • Unpleasant view of landfill. • Noise and odour.	• Most of the environmental issues will be resolved, however, leachate is still not controlled and monitoring system yet to be established.	• Leachate accumulation will be collected through drainage pipes. This will improve decomposition, odour will be reduced due to the creation of semi-aerobic conditions. • Leachate quality needs to be regularly monitored.

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OBITUARIES

May their souls rest in Peace

1. Wife of Engr. R. K. Anver, Vice-President PEC, passed away on 18, December 2012.

2. Mother of Engr. Najam Waheed, Member Executive Council PEC, passed away on 24, February 2013.

3. Mother of Engr. Amjad Raza Khan, passed away on 6, March 2013.

CONSERVATION OF WATER RESOURCES FOR SUSTAINABLE NATIONAL DEVELOPMENT

By

Shafqat Niaz Kang

ABSTRACT

Generally there is a trend of decline in annual per capita water availability. For example per capita water availability in Pakistan has been decreasing at an alarming rate due to increase in population and water requirement in other sectors. Moreover, the quality of available water resources is also declining day by day. This trend puts severe pressure on the agriculture water requirements that is the sole mean of food security in the country. The situation of decrease in water availability has become so acute that Pakistan is falling in the category of 'High Water Stress' countries. If the situation keeps on similar lines, a day will come when Pakistan will be among the water scarce countries of the world. The poverty and hunger will be the direct outcomes of this scenario. In the given circumstances there is dire need to adopt mitigation measures at national as well as individual level to cease this trend. Mitigation measures may include development of new water storage facilities, reducing water consumption and management of available water resources.

1. IMPORTANCE OF WATER

Nature has bestowed nature with the unlimited blessings and water is among the basic elements of universe. "God" has showered water from the sky and created all the living things on earth from water" . (Al-Quran)

وجعلنا من الماء کل شی ءحی

اور ہم نے آسمان سے پانی اتارا جس سے ہم نے ہر چیز کو پیدا کیا

The water is closely related with the objectives of Medium Term Framework (MTF) which stresses sustainable management and development of water resources in the country through *integrated* project and programmes. This also relates to global targets of the Millennium Development Goals (MDGs) for reducing poverty by increasing irrigated agricultural productivity, efficient management of water resources, and improving environment.

1.1. Global Context

More than two third of the Globe (over 70%) is covered with water and the rest less than 30 percent is dry. The state and occurrence of total global water resources in various pockets of globe may be narrated in following words.

- 97.5% of these resources consist of saline oceans leaving only 2.5% as fresh/sweet water resources
- This fresh water includes 70% located in frozen icecaps of Antarctica and Greenland leaving 30% approachable part having 29.5% as soil moisture & deep underground aquifers being not accessible for human consumptions i.e. 99.5% of the available fresh water is not in a usable form.
- Only 0.5% of the fresh/sweet water resources (nearly 0.007% of total global water resources) are available as surface water resources in the form of rivers, canals, lakes, shallow subsoil reservoirs etc.

Even if we consider this amount to be small still it is adequate to meet the total human requirement if the global population rises to three times of its present level. In this way the quantity of available water resources is in abundance still there is a cry of water shortage. In fact the reasons are the lack of proper management.

Likewise global scenario, in Pakistan a decrease in subsoil and surface water resources has been recognized in many governmental and international studies. The inefficient use of water has been pointed as the most serious problem leading towards water crises in the country. As per estimate Pakistan needs to double its annual agricultural food crop production after every 30 to 35 years. In such a case the food self sufficiency would no longer be possible in the near future if current water availability and low water use efficiency in agriculture prevails. Therefore, timely actions are required to implement strategies for judicial use of water as without it the country may have to face drought, hunger and poverty in the years to come. The picture showing water scarcity and drought scenario is shown in Figure-1.

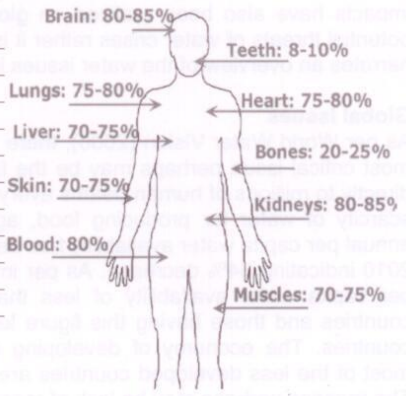
FIGURE-1 WATER SCARCITY AND DROUGHT

1.2. Human Body and Daily Life

After creating the living things from water Almighty Allah has maintained water in their bodies similar to that on the globe. The major part of human body (around 70%) consists of water. The share of water in various parts of human body is as given in Table-1.

Table 1 Water Content in Human Body

Sr. No.	Body Parts	Quantity
1	Liver	70-75
2	Bones	20-25
3	Teeth	8-10
4	Heart	75-80
5	Lungs	75-80
6	Kidney	80-85
7	Blood	80
8	Muscles	70-75
9	Skin	70-75
10	Brain	80-85



The graphical representation of proportionate share of water in human body is as given in Figure-2..

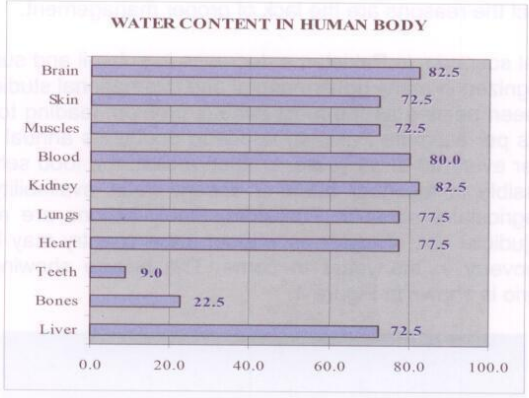


FIGURE-2 WATER CONTENT IN HUMAN BODY

In order to maintain the water balance in the human body one has to utilize certain amount of water every day. This may include the water used on account of food and drinks, bathing, washing clothes and rooms, irrigation of lawns etc. The minimum requirement of a man to survive in daily life is only 50 liters. In addition to this amount the human life is associated with water in many ways. Huge amount of water is required for preparation of food for example:

- Water Requirement for a Balanced Diet is 1,300,000 liters per capita per year i.e. 3,356 liters per day which is 70 times more than 50 liter per person per day for domestic purposes
- Water requirement to produce one loaf is 550 liters i.e. 10 times more than 50 liters per person per day
- Water required to produce 1000 grams of beef is 7,000 liters i.e. 140 times more than 50 liters per person per day

2. THE WATER ISSUE

Water crises are among the route causes of the poverty in the developing countries. Its impacts have also been realized on global level. Pakistan is not exempted from the potential threats of water crises rather it is going to be the worst victim of it. This section narrates an overview of the water issues in global and national perspective.

2.1. Global Issues

As per World Water Vision (2000), there is water crisis at global level. Although today's most critical issue perhaps may be the lack of access to clean drinking water, leading directly to millions of human deaths every year but tomorrow's crisis will definitely be the scarcity of water for producing food, agriculture and sustaining eco-systems. Global annual per capita water availability has decreased from 16,800 m^3 in 1950 to 6,100 m^3 in 2010 indicating 64% decrease. As per international criteria the countries having annual per capita water availability of less than 1700 m^3 are categorized as water stress countries and those having this figure less than 1000 m^3 are said to be water scarce countries. The economy of developing countries generally based on agriculture and most of the less developed countries are going to be among the water short countries. The reasons perhaps may be lack of resources and climate change.

2.2. National Issues

Pakistan is facing High population growth rate, economic development, changing socio-economic conditions and environmental pressures including climate change and all these are major forces behind the current water scarcity in the country. The gap between availability of water (supply) and its extensive use (demand) has been widening and during the last 50 years this gap has increased by almost 250% (Beg 2000). According to the UN comprehensive fresh water assessment, Pakistan is placed in the high water stress category (UN 1997).

Increasing demand of water for agriculture, industries, environment and household use is putting substantial pressure on the limited water resources of the country. In Pakistan the water availability and quality is currently unable to meet the economic, social and environmental needs of the country. Now the country is passing through water crises and water has become a major political, socio-economic and development issue. A significant decrease in annual per capita water availability has been observed generally on the globe but particularly in Pakistan during last few decades. In 1950, per capita availability was 5600 cubic meters that has been reduced to 1100 cubic meters by year 2010 due to increase of population from 34 million in 1947 to around 170 million. This indicates a significant decrease of 80% during this period which is 16% higher than the global decrease (i.e. 64%). Statistics show that per capita water availability in Pakistan is decreasing at an alarming rate and it puts Pakistan in the category of 'High Stress' countries in terms of limited water resources.

The statistics presented in Government of Pakistan document "Ten Year Perspective Development Plan 2001-11" the amount of available annual water resources in 2001, 2004 and 2011 are smaller than the actual water requirement in these years. Refer Table-2 for the data of water short fall in various years as reported by Pakistan Council of Research in Water Resources.

TABLE-2 : ANNUAL SHORTFALL OF WATER

Item	2001	2004	2011
Water availability (in MAF)	134.39	134.88	146.92
Water Requirement (in MAF)	141	149.8	177.4
Difference MAF	6.61	14.92	30.48
Percentage estimated shortfall	5	11	21

This table shows, in 2001 the quantity of available water resources was 134.39 MAF against the annual water requirement of 141 MAF in all sectors showing shortfall of 6.6 MAF (i.e. 5%). Similarly this shortfall raised to 11% and 21% during 2004 and 2011 respectively. Thus the shortfall between the supply (availability) and demand (total requirement) is widening with the passage of time. The graphical representation of this scenario is presented in Figure-3.

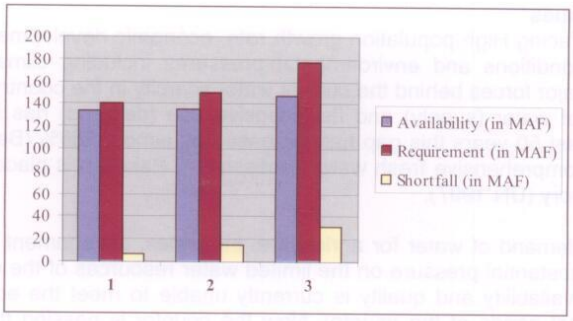


FIGURE-3 : GRAPHICAL REPRESENTATION OF SHORTFALL

Realizing this phenomenon, United Nations Environment Program (UNEP) in its latest State of the Environment reported that "Pakistan is soon going to join Water Scarce Nations of the World". This has been confirmed by the World Bank's latest publication on the Pakistan water situation, titled "Pakistan: Running Dry". Population growth, rapid urbanization, increases in per capita water consumption and climate change are considered as the reasons behind the increased water shortage in the country. Realizing this issue it is expected that, Pakistan may reach the stage of "Acute Water Shortage Country" by 2012, if appropriate measures are not taken (WAPDA, 2002). The situation is because of reduction in country's fresh water resources and the growing demand of water due to population growth; inefficient usage in agriculture, industries and household sectors; climate change; lavish use of water in various sectors and water losses during conveyance etc.

3. WATER ISSUES IN AGRICULTURE SECTOR

A major share (around 90%) of the available surface water resources currently consumed by agriculture because rainfall and subsoil water reservoirs are neither adequate nor suitable to meet crop water requirements. If water issue persists, the self sufficiency of food for the growing population would no longer be possible. Low availability of good quality water for crop production, low water use efficiency and low crop production are the major water issues of agriculture sector. This is because:

3.1. Shortage of water for Agriculture use

Here it is important to indicate that the total annual water availability include both surface water and sub-surface (ground) water. Water requirement include both agricultural and non-agricultural uses. The details in each category are given in Table-3.

TABLE-3 : WATER AVAILABILITY AT FARM GATE (MAF)[1]

Item	2001	2004	2011
Surface water	84.34	84.86	96.90
Groundwater	50.05	50.02	50.02
Total	134.39	134.88	146.92

1. Ten Year Perspective Development Plan 2001-11 (GOP, 2001)

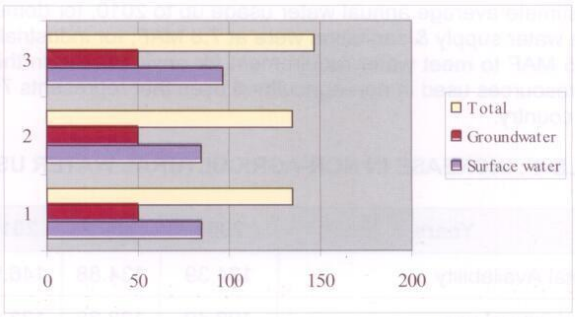


FIGURE-4 : WATER AVAILABILITY AT FARM GATE

The annual water requirement in Pakistan for 2013 is estimated at 216 MAF against the limited stock of water available to the country. Thus gap between annual availability of water (supply) and its extensive use (demand) has been widening. Estimated shortfall of water for agriculture sector alone in 2010 is expected to be 29% and is foreseen to be around 33% in 2025. It is estimated that additional 39 MAF water were required to meet the growing demand of agriculture in the country during 2011. The only mean to overcome this shortage was to utilize the subsurface water extracted through the tube wells.

3.2. Conveyance Losses

The water used for irrigation is heavily exploited due to several losses applicable to irrigation sector may include conveyance losses and field application losses. Conveyance losses in canals accounts for wastage of 15% of total water whereas the water losses from Moga to field often accounts for wastage of 25% to 65% water - thus overall water delivery efficiency is only less than 50%. The field application losses accounts for wastage of 29% of the water reaching to the farms. This shows that around 65% of the water used in agriculture sector is wasted without providing any benefit to the crops.

Water losses in the conveyance system (30-50%), low application (25-40%) and irrigation efficiencies (40%);

3.3. On Farm Losses

There is a trend in wastage of water during irrigation. The water is not applied as per crop requirements rather it is applied as per its availability. The farmers apply water as per warabandi system without considering the land moisture and rain effects. The situation leads towards the damage of crops due to improper irrigation.

3.4. Over Irrigation

Sometimes the over irrigation also leads the crops to failure as it hinders the ventilation in the subsoil strata of soil. The anaerobic conditions are not suitable for some crops like wheat, pulses etc.

3.5. Improper Leveling and Farm Layouts

The irregular farm layouts and improper leveling of fields also reduce the crop productivity of land and water. As these do not permit uniform irrigation to different parcels of the fields, therefore, the crop productivity in various sectors of the same plot changes that result in reduction in gross crop yield.

3.6. Increase in Non-Agricultural Use of Water

Historically the total non-agricultural water consumption has remained less than 5%. The share keeps on increasing substantially leaving lesser share for agriculture and industry.

As per an estimate average annual water usage up to 2010, for domestic, municipal and rural potable water supply & sanitation were at 7.8 MAF, for industrial activities were at 4 MAF and 1.5 MAF to meet water requirement for environment. In this way 13.3 MAF of fresh water resources used in non-agricultural uses that represents 7% of the total water stock of the country.

TABLE-4 : INCREASE IN NON-AGRICULTURAL WATER USAGE

Years	2001	2005	2010
Total Availability	134.39	134.88	146.92
Agricultural use	128.49	128.38	133.62
Non-Agricultural Use	5.9	6.5	13.3
%age Non-Agricultural Use	4.39	4.82	9.05

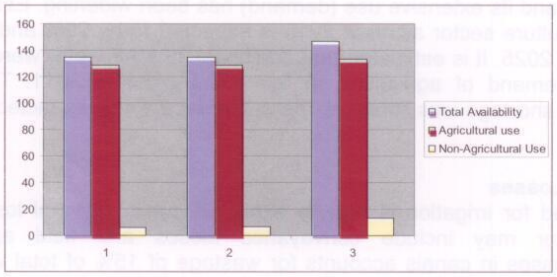


FIGURE-5 : INCREASING NON-AGRICULTURAL WATER USES

3.7. Crop Productivity per Unit of Water

In Pakistan water is being applied to the crops not according to actual needs of the crops but on rotational (varabendi) system is applicable. People irrigate their crops not as per requirement but apply water when it is made available to them. While allocating water quota in various parts of country there is neither a consideration of soil type nor the crop water requirement is taken into account. That is why the crop productivity of water in Pakistan is very low as compared to Asia's average and World average. Water productivity level for rice crops is 0.45 kg/m^3 compared with the Asia's average water productivity level of 1 kg/m^3. Similarly the water productivity level for wheat crop is 0.76 kg/m^3 comparing with the world's average level of 1 kg/m^3. Our National crop productivity of water compared with other countries is as given in Table-5.

TABLE-5 : AV. CROP PRODUCTIVITY PER UNIT OF WATER

Sr. No.	Year	Kg/m^3
1	Canada	8.72
2	USA	1.56
3	China	0.82
4	India	0.39
5	Pakistan	0.13

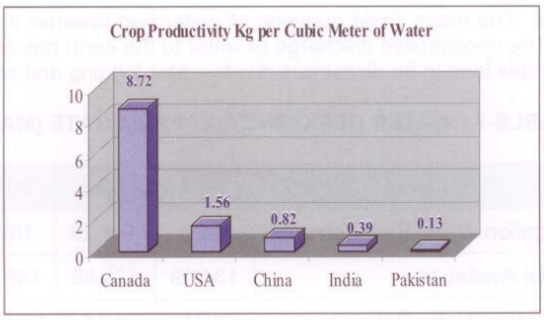


FIGURE-6 : CROP PRODUCTIVITY OF WATER

It is evident from the data that the crop productivity of rice in Pakistan is 55% below the average produce value in Asia and also the productivity of wheat in Pakistan is 24% less than the world average. To enhance crop yields and water use efficiencies it is necessary that water may be applied to the crop on the basis of actual needs of the crops.

4. CROSS SECTORAL ISSUES

Factors responsible for water scarcity in the country, higher water consumption, increased non-agricultural usage and our wasteful attitude in various sectors are briefed in the following lines:

4.1. Smaller Storage Arrangements

The country has inadequate water storage capacity due to which more than 36 MAF (nearly 25%) out of total fresh water resources is going untapped to sea annually with out its utilization within the country. The country's overall current storage capacity is less than 9 per cent of average annual flows, is very low compared with the world average of 40 per cent. The average annual per capita water storage capacities of various countries comparing with Pakistan are presented in Table-6.

Moreover the storage capacities of existing water reservoirs in the country have significantly been reduced, a reduction from 15 MAF to 11 MAF means more than 25% of the reduction. This not only necessitates the requirement for de-silting and capacity enhancement of existing dams and the requirement of new dams of acceptable sizes.

TABLE-6 : WATER STORAGE CAPACITIES OF VARIOUS COUNTRIES

Sr. No.	Country	Per capita Storage (m^3)	Carry over Capacity (days)
1	USA	6000	900
2	Australia	5000	600
3	India	150	120-220
4	Pakistan	130	30

4.2. Exploitation of Subsoil Water Resources

Due to scarcity of surface water, the overall sub-soil water consumption in Pakistan has risen to 48.69 MAF. Province wise distribution shows Punjab at 42.69 MAF; Sindh at 3.5 MAF; NWFP at 2 MAF and of Baluchistan at 0.5 MAF level. The installation of private-sector tube-well irrigation and other uses has had its serious environmental

consequences. The mass scale pumping of water had lowered the subsoil water table significantly. The uncontrolled discharge of water to the earth has also caused millions of hectares of arable land to be disastrous due to water-logging and salinity.

TABLE-7 : WATER DEFICIENCY AT FARM GATE (MAF)[1]

Item	2001	2005	2010
Irrigation Water Requirement	135.1	143.29	169.6
Total Availability	134.39	134.88	146.92
Irrigation Water Deficiency	0.71	8.41	22.68

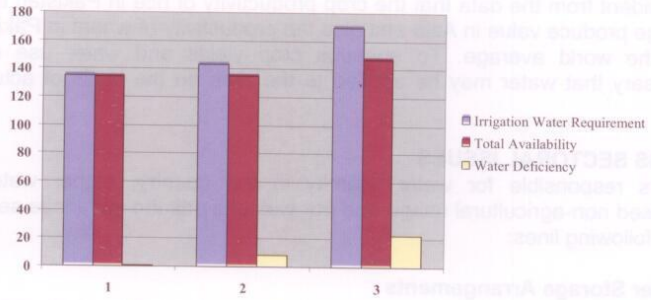


FIGURE-7 : WATER DEFICIENCIES AT FARM GATE

4.3. Municipal and Domestic Sector

The Municipal and Domestic sector water requirements of the urban and rural areas of country are also increasing with the passage of time. Per capita per day water consumption in Pakistan is 400 liters comparing with 200 to 300 liter in USA, 122 in Iran, 300 in India, 215 in China. This higher water consumption results in heavy discharge of effluent from urban and municipal areas. As per PCRWR study, the municipal discharge from six major cities of Pakistan (i.e. Karachi, Lahore, Peshawar, Faisalabad, Rawalpindi / Islamabad and Multan) is recorded at more than 6.5 million m^3 per day including 4.5 million m^3 of domestic and 2.0 million m^3 from Industrial areas[2]. The pollution generated by domestic sector is so high that more than 2 million tons of urban excreta are produced in the country every year and 50% of this ends up directly in the natural water resources. Therefore one of the reasons of sub-soil water contamination is the disposal of Municipal effluent per year.

The entire quantity of urban sewage is being discharged to the surface water bodies and open land. This adds to the contamination of land and surface water bodies having toxic chemicals and high nutrients level. The increased land contamination and use of inferior quality of water for irrigation reduces the per acre productivity of crop. Moreover, the prevailing Municipal Water Supply Systems in the country are heavily wasteful leaving the lesser amount of fresh water for irrigation. According to government reports, in Islamabad only the quantity of 'unaccounted for water (water lost between source and consumer) is more than 60 percent of the total supply. This scenario is even worst in other cities of the country.

1. Ten Year Perspective Development Plan 2001-11 (GOP, 2001)
2. Dr. Muhammad Akram Kahlon and Dr. Muhammad Ashraf (PCRWR, 2007)

4.4. Industrial Sector

Millions of tons of toxic effluent from the industries are being discharged to the rivers and other surface irrigation / drainage channels every day. As per available statistics 99% of the total effluent discharged from these industries is being discharged to open land and surface waters without any treatment i.e. only 1% of Industrial Effluent is currently being treated. Sugar industry of Pakistan produces 360,000 tons of sugar every day generating 0.4 to 2.0 m^3 of polluted effluent per ton that accounts for 0.11 MAF per year. Around 800 leather industries of Pakistan located in Karachi, Lahore, Sialkot, Kasur, Multan and other cities produces more than 40,000 m^3 per day. The discharge of polluted industrial effluent from NWFP to Kabul River only is 80,000 m^3 per day.[1]

4.5. Water Losses during the Monsoon Season

A major share of sweet water resources of the country received from irrigation flows to the sea as floods due to improper management arrangements for it. This not only causes floods associated with regular monitory losses but also results in deficiency of water after the end of monsoon season. During monsoon season 36 MAF un-tapped waste water goes to the sea annually due to inadequate water storage. The other losses associated with the monsoon rains are listed as below:

- Floods and loss of livestock
- Water over flowing to the sea
- Floods adding water logging and salinity
- Damage to crops and livestock

4.6. Water Quality Issues

The surface and sub-soil water contamination is also a serious threat to the subsisting water resources. The studies suggest that this water contamination is higher in vicinity of human settlements and industries. In this regard National study on the quality of water carried out by Pakistan Council of Research in "Water Resources (PCRWR) in 21 cities, 6 rivers and 10 reservoirs and lakes" suggests that bacterial contamination is very frequent in the country, particularly with the pressure of coliform in 17 cities, bacterial contamination is greater than 50% and in 4 of these cities 100% of the samples were considered as unsuitable for human consumption. The inorganic contamination is also very high particularly with fluorites sulphur and sulphate. Another study launched in 2004 indicated that no appreciable improvement has been made in the above described conditions. Widespread water pollution has resulted in increased fresh water scarcity; poorer public health; lower agricultural yields and a declining quality of aquatic life in lakes, rivers, and coastal waters. The pollution of water bodies has also increased the incidence of waterborne diseases in rural and urban areas. Water and land Losses due to its Quality Deterioration are listed below:

- Quality of Municipal waters as were used for irrigation is being deteriorated due to discharge of Municipal Pollution
- The use of sub-soil water and kitchen waste water for irrigation purposes causes Salinity of land and reduced crop yield
- The excessive discharge of highly polluted water in soil or its usage in irrigation results in deterioration of rich agriculture lands

5. HOW TO ADDRESS THESE PROBLEMS

- It is inevitable to increase the storage capacity of the country.

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1. Data base of Water Resources, UNDP Pakistan (July 2009)

- As per estimates without additional storage, the shortfall will increase by 12 per cent over the next decade. Increasing storage capacity should be an important part of our national planning and strategy.
- Additional agriculture water demand may be minimized through higher irrigation efficiencies. The target may be achieved through increasing share of non-irrigated or well-irrigated area in newly cropped areas.
- Municipal and industrial discharge of effluent may be minimized by using better house keeping and management techniques at individual user level. The treatment of the subsisting effluent may help reduce the pollution load in the receiving bodies of these discharges. Recycling of selected wastes for some appropriate purposes may reduce the overall water usage.
- The overall water use efficiency should also be increased through groundwater recycling and recharge
- The large storages should be complemented by a comprehensive program integrated with plans for establishing small dams, delay action dams and other measures for recharging underground reservoirs.
- The water productivity level of various crops should also be enhanced. This may be possible by increasing tariff rates of irrigation water and reducing quantities of water allocated to the farmers and enhancing the supply to the barren lands.
- Water conservation and its management for Municipal and/or Industrial areas should be ensured through installation of water meters
- No Municipal and / or Industrial effluent should be permitted to be disposed / discharged into the natural water resources without prior treatment as well as up to certain acceptable level as indicated in NEQS
- Groundwater depletion should be controlled by increasing canal supplies, increasing recharge through recharge basins and controlling groundwater pumpage where appropriate.

IDENTIFICATION OF TREE SPECIES COMPROMISING FOR WATER SHORTAGE

By

Dr. Muhammad Afzal*

Introduction

Sajjad (2004) describes the climate of Pakistan as dry and hot near the coast, becoming gradually cooler towards the northeastern uplands. Winter is generally cold and dry. The hot season starts in April and by end of June, temperatures may reach 49 °C. Between July and September, the monsoon provides an average rainfall of 38 cm (15 inch) in the northern areas. Rainfall can differ immensely from year to year, and successive pattern of flooding and droughts appear.

Pakistan lies entirely outside the tropics although the climate is classified as a tropical climate, more specifically tropical monsoon climate. However, the monsoon is short lived, so the climate comes to be continental semi-arid. During summer Pakistan is considered meteorologically to be a tropical climate region, and in winter, subtropical. The country has a continental climate with little rainfall (Kheli, 1997).

Parry et al. (1998) claim that like the weather, climate is also changeable. The climate of any region is not precisely the same from one year to another. The climate change can be defined as the 'change in the average climate (or its variability) from one averaging time to the next.' Overall, it is evident that the 20th century has been the warmest century for 1400 years. It is essential to review the impact of climatic change on sea level, rainfall pattern, aridity, changes in land use, forestry & agriculture, and that of water resources for the improvement of the region.

From the world climatic record since 1861, it is evident that temperature rise is between 0.3 °C to 0.6 °C. However, this significant change is irregular. Pakistan, as part of South Asia has also observed warming in spite of less discharge of green house gases as compared to industrialized developed countries (Pant and Kumar, 1997).

Environmental threats are increasing tremendously. Climate change and global warming are linked with these environmental degrading scenarios. Global warming and climate change are used synonymously but climate change gives a wider sense of the meaning. Being a global phenomenon, the impact of climate change has become critical for the world. Underdeveloped or developing countries like Pakistan would have to face additional damages because of their unstable situation. Some pollutants produced by different human activities are increasing the percentage of greenhouse gases (GHG) emission in the atmosphere. The most important of these are CO_2, CH_4, N_2O, CFCs, water vapour and other industrial gases. Solar radiation reaches the outer limits of the atmosphere without loss. But afterwards reduction starts by reflection, depletion and absorption in different parts of atmosphere. The Earth radiates long wave or infrared radiation back to the space in relevant proportion. But GHG act as cover for outgoing weak long wave radiation. This radiation is trapped by clouds and GHG, and enhances the warming of atmosphere, causing global warming. Global warming is no more just a theory: it is affecting millions of people around the world in terms of harsh weather, droughts, flood, heat waves, cyclones and anti cyclones (Mustafa, 2007).

Latif and Tariq (2006) while discussing the Indus Irrigation System of Pakistan discuss the importance of rainfall, as a source of water. However, the rain is variable and insufficient for crop growth. A large portion of the rainfall (about 70%), floods the area or flows into the sea without serving any use and often causing misery to the villages and towns. The Plains of Sindh get more rainfall during July-August with a declining trend from coastal to central Sindh. Southern Punjab and Northern Sindh are areas of low rainfall having 152 mm as an annual

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average. The areas above the Salt Range get a higher annual average of 635 mm, including districts of Jhelum, Rawalpindi, Attock and Mianwali. The water in Indus Plains and Peshawar Valley is 26 MAF (31.82 BCM) but its contribution to the crops is about 6 MAF (7.34 BCM) in the irrigated areas. Khan (1988) states the average rainfall range from 10 mm to 1000 mm. He estimates the runoff losses from cultivated portion of rainfall area equal nearly 6 MAF (7.34 BCM). If water loss from rangelands and forest region is added then this loss rises to 18 MAF (22.03 BCM) approximately. If 25% of this loss is conserved and stored i.e., 4.5 MAF (5.5 BCM), it can further be managed for proper utilization in crop and power sector for a visible change in barani backward areas on social, economic and agricultural bases.

Materials and Methods

According to Rahim (2011), Changa Manga irrigated plantation covering an area of 12510 acre (5065 hectare) falls in the semi arid, subtropical continental zone of central Punjab and is characterized by high temperature, low relative humidity, erratic and irregular rainfall. The summers from April to September are extremely hot while the winters from mid November to end of January are sufficiently cold. The monsoons generally break during July and August when heavy showers of rain are received. The plantation receives irrigation water during kharif only i.e. from 16th April to 15th October. However, the actual number of flow days seldom exceeds 168 in a year. At the rate of 12 cusec per 1000 acre (400 hectare), the minimum requirement of Changa Manga including 10% absorption losses worked out to be 165 cusec. Since the average number of flow days per annum is 147 and the average discharge received during the last 10 years is 109.9 cusec, the present supply is, therefore, only 58% of the minimum requirement.

Shisham (*Dalbergia sissoo*) has been the apex species of irrigated plantations in Punjab which is now becoming the victim of dieback. Possible causes for dieback in Shisham investigated by Afzal et al. (2006) include Physiological stress as primary cause accrued by drought, lopping, over maturity, poor planting stock, and Pathogenic attack as secondary cause as a result of physiological stress rendering trees vulnerable to pathogenic attack. Study conducted by Shukla (2002) at Forest Research Institute (FRI), Dehra Dun, India highlights the following factors responsible for Shisham dieback: Environmental factors; include global warming which appears to be the major causal factor due to increase in mean temperature. Hydrological factors; include erratic rains responsible for change in atmospheric humidity and sub-surface water level. Pathological factors; include *Fusarium solani* and *Ganoderma lucidum* responsible for root rot in Shisham causing large-scale destruction. Survey report indicates 10-40 % mortality in block plantations, road and canal sides. State level surveys indicate 60-90 % mortality in U.P and 70-87 % in Punjab (India).

An arboretum was established by Punjab Forest Department at Changa Manga during early fifties of 20th century on an area of 9.5 acres. About 75 tree species, indigenous and exotic have been raised there. Data regarding height and diameter (at breast height) were collected to assess the growth of some promising species.

Results and Discussion

To assess the performance and rate of growth, Mean Annual Increment (MAI) of different species was calculated which is presented in Table-1.

Table-1: Mean annual increment of different tree species

S. No.	Tree Species	Age (year)	Diameter (inch)	Height (foot)	Volume (cft)	Mean Annual Increment (MAI)
1	Taxodium	54	26	67	247.0	4.6
2	Bischofia	54	20	56	122.2	2.3
3	Silver Oak	46	15	49	60.1	1.3
4	Millettia	22	19	44	86.6	3.9
5	Mahagony	22	10	33	18.0	0.8
6	White Siris	54	21	68	163.6	3.0
7	Gulkain	43	21	55	132.3	3.1

8	Lakuch	22	20	52	113.4	5.2
9	Molsari	20	8	29	10.1	0.5
10	Arjun	53	18	53	93.7	1.8
11	Ehretia	52	13	39	35.9	0.7
12	Sagwan	52	15	47	57.7	1.1
13	Gul-e Fanoos	24	24	51	160.2	6.7
14	Kusum	22	13	38	35.0	1.6
15	Chir	51	16	56	78.2	1.5
16	Casuarina	24	11	43	28.4	1.2
17	Mogabo	24	17	52	82.0	3.4
18	Tun	54	29	68	311.9	4.6

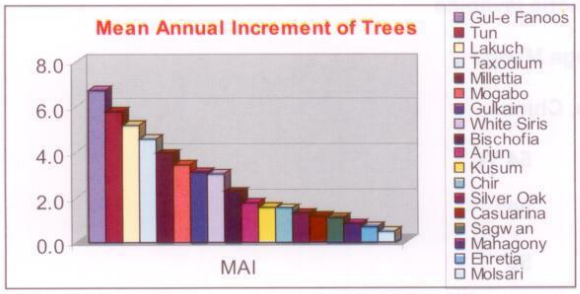


Fig-1: Mean annual increment of different tree species

TAXODIUM

Tech. Name: Taxodium distichum

Location: **Changa Manga**

Origin: **America**

Age: **54 Yr.**

Dia: **26"**

Ht.: **67'**

Uses: The trees are especially priced for their wood, of which the heartwood is extremely rot and termite resistant.

BISCHOFIA

Tech. Name: Bischofia javanica

Location: Changa Manga

Origin: India, China

Age: 54 Yr.

Dia: 20"

Ht.: 56'

Uses: The dark red, dense wood is used as a building material. The seeds, which are edible, contain 30-54% oil, which is used as a lubricant.

SILVER OAK

Tech. Name: Grevillea robusta

Location: Changa Manga

Origin: Australia

Age: 46 Yr.

Dia: 15"

Ht.: 49'

Uses: Before the advent of aluminium, the timber from this tree was widely used for external window joinery as it is resistant to rotting. It was also popular for making furniture.

MILLETTIA / WALAITI SHISHAM

Tech. Name: Milletia ovalifolia

Location: **Changa Manga**

Origin: **Burma**

Age: **22 Yr.**

Dia: **19"**

Ht.: **44'**

Uses: Wood is used for furniture.

MAHAGONY

Tech. Name: Swietenia mahagoni

Location: **Changa Manga**

Origin: **India**

Age: **22 Yr.**

Dia: **10"**

Ht.: **33'**

Uses: Good quality timber used in furniture. The word Mahagony is a Hindi word which is made of two basic words Maha+Gony, which means great (maha) qualities (gony).

WHITE SIRIS

Tech. Name: Albizzia procera

Location: Changa Manga

Origin: India, Bangladesh, Burma

Age: 54 Yr.

Dia: 21"

Ht.: 68'

Uses: Wood is durable, strong and resistant to termites used for furniture, boats, flooring, posts, agriculture implements, etc.

GULKAIN

Tech. Name: Trewia nudiflora

Location: Changa Manga

Origin: India, China, Malaysia

Age: 43 Yr.

Dia: 21"

Ht.: 55'

Uses: Used for furniture and construction.

LAKUCH

Tech. Name: Artocarpus Lakoocha

Location: Changa Manga

Origin: India, Bangladesh

Age: 22 Yr.

Dia: 20"

Ht.: 52'

Uses: The tree is valued for fodder and timber. The hardwood sold as lakuch, is comparable to famous teak wood. Lakuch durable outdoors as well as under water, is used for construction, furniture, boat making and cabinet work.

MOLSARI

Tech. Name: Mimusops elengi

Location: Changa Manga

Origin: India

Age: 20 Yr.

Dia: 8"

Ht.: 29'

Uses: wood is Luxurious, extremely hard, strong & tough timber. Rich deep red in colour. Works easily & takes beautiful polish.

ARJUN

Tech. Name: Terminalia arjuna

Location: **Changa Manga**

Origin: **Local**

Age: **53 Yr.**

Dia: **18"**

Ht.: **53'**

Uses: It is a unique herb that helps maintain a healthy heart, reduces the effects of stress & nervousness and regulates blood pressure. Also used as timber.

EHRETIA

Tech. Name: Ehretia acuminata

Location: **Changa Manga**

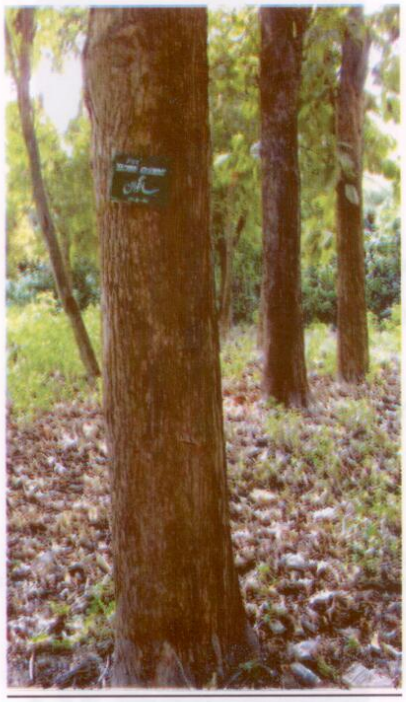
Origin: Local

Age: 52 Yr.

Dia: 13"

Ht.: 39'

Uses: Used for building, agricultural implements and gunstocks.



SAGWAN

Tech. Name: Tectona grandis

Location: Changa Manga

Origin: Burma, Bangladesh

Age: 52 Yr.

Dia: 15"

Ht.: 47'

Uses: Teak is used extensively in India to make doors and window frames, furniture and columns & beams in old type houses. It is very resistant to termite attacks. Mature teak fetches a very good price. Teak is easily worked and has natural oils that make it suitable for use in exposed locations, where it is durable even when not treated with oil or varnish.

GUL-E FANOOS

Tech. Name: Kigelia pinnata

Location: **Changa Manga**

Origin: **Africa**

Age: **24 Yr.**

Dia: **24"**

Ht.: **51'**

Uses: Kigelia is a forest tree and will grow in either sun or shade but requires a good deal of space and is reasonably drought hardy. The wood is easy to work and produces a good quality timber for general use.

KUSUM

Tech. Name: Schleichera trijuga

Location: Changa Manga

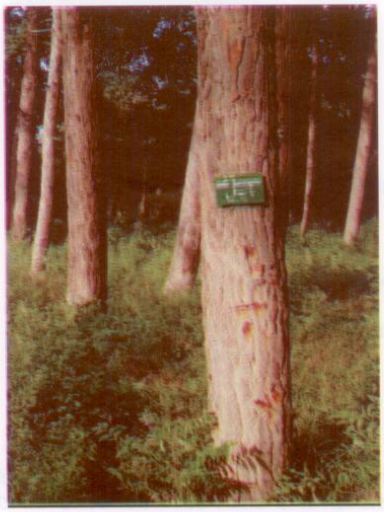
Origin: Africa

Age: 22 Yr.

Dia: 13"

Ht.: 38'

Uses: The fruit is edible and oil obtained from the seeds is an item of commerce in India. One of the chief uses of the tree is for the propagation of lac. (is the scarlet resinous secretion of a number of Insects final product is seedlac) Silviculturally the tree is useful as shade and protection to the soil.



CHIR

Tech. Name: Pinus roxburghii

Location: Changa Manga

Origin: Local

Age: 51 Yr.

Dia: 16"

Ht.: 56'

Uses: Widely used for timber. Also planted in parks and gardens in hot dry areas, where its heat and drought tolerance is valued. It is also tapped commercially for resin. The resin yieds an essential oil, commonly known as turpentine and non-volatile rosin.

CASUARINA

Tech. Name: Casuarina equisetifolia

Location: **Gatwala**

Origin: **Local, India, Nepal, Burma**

Age: **24 Yr.**

Dia: **11"**

Ht.: **43'**

Uses: The wood of Casuarina is dark brown, very hard (density 1000 kg/m3), resistant to decomposition in soil or saltwater. It is often used as round wood for making piles, poles and fences, popular as lumber, used for house beams and furniture. Because of its high calorific value (5000 kcal/kg), its wood is an excellent source of fuel and charcoal.

MOGABO

Tech. Name: Acacia albida

Location: Gatwala

Origin: Africa

Age: 24 Yr.

Dia: 17"

Ht.: 52'

Uses: One of the fastest growing indigenous trees in South Africa. Drought-resistant, medium to large tree, used for firewood, charcoal, construction, posts, utensils, flavouring (pods), medicine (bark), fodder (pods and leaves), mulch, shade, nitrogen fixing, soil conservation and improvement, windbreak, tannin, dye (bark, roots), canoe marking etc.

TUN / AUSTRALIAN RED CEDAR

Tech. Name: Cedrela toona

Location: Changa Manga

Origin: Local, India, Nepal, Australia

Age: 54 Yr.

Dia: 29"

Ht.: 68'

Uses: Furniture, fodder, ornamental, timber, medicinal (bark for dysentery), shade, construction, etc.

Conclusion

It is concluded from the study that the above mentioned mesophytes compromising for water shortage can perform well.

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ISOLATION AND IDENTIFICATION OF BACTERIA FROM BENCH SCALE MEMBRANE BIOREACTOR (MBR) SYSTEMS

By

Fozia Parveen, Sana Jehan Ansari and Sher Jamal Khan[1]

Abstract

The principal objective of municipal waste water treatment is generally to allow human waste to be disposed without posing any danger to the human health or causing unacceptable damage to the natural environment. Untreated waste water contains a large number of microorganisms that are pathogenic, but at the same time can be used to treat the waste water provided the optimum conditions to do so. Membrane Bioreactor (MBR) is an advanced tertiary waste water treatment that combines biological process and membrane technology. In this study, three MBRs were installed at bench scale 1) Conventional MBR (C-MBR), 2) Moving Biofilm MBR (MB-MBR) and 3) Anoxic-Oxic Growth MBR (A/O-MBR). The bacteria in each of these reactors were isolated by plating them on nutrient agar after several dilutions and the colonies were counted. The maximum number of colonies were found in the A/O-MBR, with CFU/ml count of 8.3×10^8. The CFU/ml count was 1.5×10^8 and 5.1×10^7 of MB-MBR and C-MBR respectively. These results were found to be consistent with the MLVSS concentrations in these three reactors, proving that Plastic (kaldnes) media enhances and promotes the growth of microbes. Different bacteria were isolated by picking them from the dilution plates, followed by pure culture technique. The colony morphologies of the bacteria in all three reactors were recorded and the majority of them were found to be circular with off-white to milky-white color, differing slightly in their texture and margin. Eleven bacteria were isolated from each of the three reactors. For the identification of these bacteria, they were gram-stained, and only one strain in each of these reactors was found to be gram positive. A total of four additional biochemical tests were carried out on each of these bacteria, which consisted of plating them on 1) MacConkey agar, 2) EMB agar, 3) Simmons Citerateagar, and 4) Brilliant Green agar. The lactose fermenting bacteria of A/O-MBR were found to be 8%, 50%, 31% and 15.4% for each of the above tests respectively. The percentages of lactose fermenting bacteria for the two other reactors were found in similar manner. The Total Nitrogen Removal (TN) and Total Phosphorous (TP) removal efficiencies were maximum at 70.7% and 68.2% respectively in A / O MBR, proving the isolation of *Pseudomonas aeruginosa* only in this reactor by plating the effluent on Citrimite agar (Oxoid, UK). These tests were later confirmed using the API Testing from 20 E kit (bio-Meurix, Canada).

Key Words :

API : Analytical Profile Index
MBR : Membrane Bioreactor
SRT : Sludge Retention Time
MLSS : Mixed Liquor Suspended Solids
MLVSS : Mixed Liquor Volatile Suspended Solids
TP : Total Phosphorous

Introduction

Membrane bioreactor is becoming widely applicable for biological waste water treatment (Duan et al., 2009). MBR is a combine conventional activated sludge treatment with a membrane solid liquid separation process (Bhatti et al., 2009). In such type of biological treatment the biological flocs and biofilms are used for degrading or adsorbing dissolved colloidal, settleable and particulate matter (Henze et al., 2008). Microorganisms are responsible for most of the carbon and nutrient removal from waste water (Wagner & Loy, 2002), therefore, it is important to get an in-depth knowledge of the kind of microorganisms present in biological treatment systems.

Membrane bioreactors can be operated to ensure simultaneous nitrification and denitrification as well as phosphorus removal .Maintenance of higher SRT ensures better treatment of waste

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water. Increased MLSS concentration decreases the reactor volume and results in smaller footprint. The effluent can be of greater quality since the higher SRT ensures retaining microorganisms that are important for waste water treatment such as *Nitrosomonas* and *Nitrobacter*. However the frequent maintenance of MBR, its energy intensiveness and membrane fouling are the drawbacks of membrane bioreactors (Melin et al., 2006).

The advancements in molecular techniques have enabled detection and reliable quantification of bacteria in waste water (Roberts & Lewis, 2001).Bacterial species of prime importance such as *Nitrobacter, Nitrospira* (Ce´bron & Garnier, 2005), *Nitrosospira, Nitrosomonas* (Hiorns et al., 1995), *Pseudomonas* (You, 2005), *Bacillus*(Lin et al., 2007) etc have extensively been evaluated using molecular techniques such as PCR-DGGE and FISH. However the understanding of structure and diversity of bacterial community in MBRs treating municipal waste water is not well understood (Duanet al., 2009). The diversity of all bacterial species and other microorganisms of different membrane bioreactor systems have not been completely evaluated, therefore, the aim of this study was to isolate and characterize bacteria present in membrane bioreactor systems and compare it with the performance of the reactor.

Materials and Methods

In this study, three submerged hollow fiber MBRs were installed at bench scale 1) Conventional MBR (C-MBR), 2) Moving Biofilm MBR (MB-MBR) and 3) Oxic/Anoxic MBR (A/O-MBR). These acrylic reactors were divided into three compartments and hollow fiber MF membrane was submerged in middle compartment (Mitsubishi Rayon, Japan) having 0.1µm pore size and $0.2m^2$ surface area. The reactors were fed with synthetic waste water (Glucose, NH_4Cl, KH_2PO_4, Na HCO_3 (Buffer), $CaCl_2$, Mg_2SO_4, $FeCl_3$, $MgCl_2$) with COD : N : P of 100 : 10 : 2. Peristaltic pump (Master Flex, Cole-Parmer, USA) with two minutes filtration and two minutes relaxation time was used to draw the permeate. The reactors were operated at an SRT of 30 days and HRT of 8 hour.

Isolation of bacteria

Samples were collected from membrane bioreactors at the same time and relatively same place of the bioreactor. Serial dilutions were performed upto 10^{-7} and were plated on nutrient agar plates. Morphologically different colonies were marked and picked for further isolation and streaked until obtaining a pure colony.

Plating Methods

Spread plate method was followed for plating the sample on nutrient agar plates. Dilutions were mixed and 0.1 ml of all dilutions was added on nutrient agar plate and evenly spread with the help of a glass spreader. The petri plates were incubated in inverted position at 37ºC for 24 hours. Colonies with different morphological characteristics were isolated through streak plate method. The marked colonies were picked and purified on separate nutrient agar plates.The colonies were observed for colour, size, shape, elevation, texture, margin and pigmentation. Their cell morphology was found using Gram staining.

The isolates were then grown on 1) MacConkey agar, 2) EMB agar, 3) Simmons Citrateagar, 4) Brilliant Green agar and 5) Citrimite agar.

Identification of bacteria

The Gram negative isolates were identified by API 20 E (biomeurix, Canada) according to the instructions provided by the manufacturer. The seven digit code was added into API web software for isolate identification (Table-5).

Analytical Methods

The techniques adopted to investigate chemical parameters are listed in Table-1.

Table-1 : Analytical parameters

Parameter	Method	Equipment	Reference
MLSS/MLVSS (Mixed liquor suspended solids/ Mixed liquor volatile suspended solids)	Filtration-Evaporation	MLSS (Oven 105°C) MLVSS (Muffle Furnace 550°C) And GF/C, What man (1.2 µm)	APHA et al., 2005
COD (Chemical oxygen demand)	Close Reflux	COD Reactor 150°C	
NH_4-N, NO_2^-N, NO_3^--N	Hach Reagents	Spectrophotometer (DR 2010, Hach)	
TN	NDIR	TOC Analyzer	---

Results and Discussion

The results obtained for colony counting showed that A/O-MBR allows the growth of maximum microorganisms as compared to that of MB-MBR and C-MBR (Table-2).

Table-2 : Comparison of colony counts for all three reactors

Reactor	CFU/ml
C-MBR	5.1×10^7
MB-MBR	1.5×10^8
A/O-MBR	8.3×10^8

The morphological examination of isolates revealed that the colonies of the C-MBR were mostly circular in form, had raised elevations and the margins were mostly smooth, although some were found to be lobate and undulate. A majority of them looked opaque, varied in colour from off-white to dark yellow, glistening and their sizes ranged from 0.1 to 0.2 cm.

In contrast to this, all MB-MBR colonies were smooth and circular in shape, mostly pasty in texture and off-white in colour that appeared golden brown under a light microscope.

The colonies of A/O-MBR were similar to those of C-MBR in terms of shape, elevation, texture and colour. The sizes of these colonies were different, however, as they varied from < 0.1 cm to 0.4 cm. The sizes of the colonies of C-MBR, MB-MBR were more or less similar, with the smallest colonies found in the MB-MBR. Whereas the cell morphology showed only one isolate in each reactor to be Gram positive with the remaining being Gram negative.

Table-3 : Growth of isolates on various media

Reactor	No of isolates	Eosin Methylene Blue Agar	Simmons Citrate Agar	MacConkey Agar	Brilliant Green Agar	Citrimite Agar
C-MBR	11	8	8	8	3	nil
MB-MBR	11	7	7	4	4	nil
A/O-MBR	11	8	8	5	5	yes

Most of these mediums presented in Table-3 support growth of gram negative bacteria only. Growth of the isolates can be related to their activity where A/O-MBR and C-MBR isolates showed similar activities followed by MB-MBR isolates. Several platings of the sample on citrimide agar allowed isolation of *Pseudomonas aeruginosa* from A/O-MBR only showing that maintenance of lesser DO allows the growth of important denitrifying microorganisms.

Parallel to the microbial analysis, performance of the reactors was evaluated in terms of nutrients (P, TN) removal and Nitrate and Nitrite removal. The results as percentage removal are shown in Table-4.

Table-4 : Treatment performance comparison of three MBRs for P, COD, TN, NO_3^{1-}, NO_2^{1-} removal and pH

Reactor	Phosphorous Removal (%)	Nitrate NO_3^{1-} Removal (%)	Nitrite NO_2^{1-} Removal (%)	Total Nitrogen Removal (%)	pH	COD Removal (%)
C-MBR	41	76	95	60	7.80	95.0
MB-MBR	45	79	95	70	7.87	96.0
A/O-MBR	57	90	98	83	8.00	96.4

Treatment efficiency is observed to be the highest for A / O-MBR followed by MB-MBR and C-MBR which proves that modifications such as addition of media (MB-MBR) and addition of media and Anoxic-Oxic combination (A / O-MBR) improves the performance of conventional MBR.

Table-5 : API 20 E identification of the isolates

C-MBR	MB-MBR	A/O – MBR
Pseudomonas fluorescens/putida	*Klebsiellapneumoniaessppne umoniae*	*Burkholderiacepacia*
		Pseudomonas aeruginosa
Pseudomonas oryzihabitans	*Grimontiahollisae*	*Pseudomonas fluorescens/putida*
Klebsiellaoxytoca	*Pseudomonas oryzihabitans*	*Yersinia ruckeri*(possibility)
Pantoeaspp	*Pasteurellapneumotropica*	*Raoultellaterrigena*
Klebsiellapne umoniaesspozaenae	*Klebsiellaoxytoca*	*Klebsiellaoxytoca*
	Non fermentor	*Myroidesspp/Chryseobacterium indologenes*
Erwiniaspp(possibility)	*Vibrio fluvialis*(possibility)	*Bordetella/Alcaligenes/Moraxella spp*

Pseudomonas are known for their diversity and their growth in all kinds of environment (Peixet al., 2009) similarly from all three membrane bioreactors almost all kinds of Pseudomonas species were isolated that include *Pseudomonas fluorescens / putida, Pseudomonas oryzihabitans* and *Pseudomonas aeruginosa* with the first two isolated from all reactors while last from A/O-MBR only. This implies that *Pseudomonas fluorescens / putida, Pseudomonas oryzihabitan* scan grow at higher DO as compared to *Pseudomonas aeruginosa.*

Klebsiellaoxytoca has been studied (Abd-al-haleem et al., 2007) for its ability to reduce nitrite in waste water and is, therefore, a nitrifying bacteria. This specie was isolated from waste water of all three reactors. Chen et al., (2008) studied *Klebsiellaoxytoca* for its ability to degrade cyanide, so along with nitrification it can perform other important functions as well. Similarly *Pantoeaspp* has been evaluated for biosorption of Cr, Cd, Cu and other industrially important metals (Ozdemir et. al., 2004). Majority of the colonies belonged to the *Enterobacteriaceae* family such as *Klebsiella pneumonia sspozaenae, Erwiniaspp, Raoultellaterrigena, Klebsiellaoxytoca* and *Pantoea spp.* Members of this family are Gram negative rods and are facultative anaerobic in nature and non spore formers.

Conclusion

Activated sludge in all three reactors is dominated by *Pseudomonadaceae* family followed by *Enterobacteriaceae*, one *Vibrionaceae* specie and so on. Overall it can be suggested that Membrane Bioreactor of any kind is helpful in retaining microorganisms important for waste water treatment and are indeed a better option as compared to activated sludge treatment systems. There in not much difference in the microbes isolated from the reactors while their overall performance in terms of organic removal is also more or less the same except that addition of media and mechanical mixer placement and therefore, lesser DO maintenance has enabled better treatment performance by supporting other important waste water microorganisms such as *Nitrosomonas* and *Nitrobacter*. Species identified by API recommend that the reactors are suited to treatment of industrial waste water as well, as the isolates are potential species found in industrial waste water treatment.

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